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ORIGINAL ARTICLES.

I.—Notes on *Elephas* (*Stegodon*) *ganesa*, Falc. & Caut., from the Pliocene Deposits of the Sewalik Hills, India.

By Henry Woodward, LL.D., F.R.S., F.G.S., etc.

(PLATE XIV.)

INDIA, the present home of one of the two types of existing elephants (*Elephas Indicus*), has also yielded abundant evidence of numerous extinct forms of this animal; two species of *Dinotherium*, eight species of *Mastodon*, and seven species of extinct elephants being recorded from the Miocene and Pliocene formations of that great continent.

Elephas ganesa, the subject of these notes, was probably one of the largest of all the fossil elephants known, and is represented in the Geological Gallery of the British Museum (Natural History), Cromwell Road, by a skull from the Sewalik Hills, India, the tusks of which measure 10 feet 6 inches in length outside the alveolar portion, and 2 feet 3 inches more within the alveolus.

This superb specimen, presented to the Trustees in 1848 by General Sir William Erskine Baker, K.C.B., has quite recently been remounted in an improved position in the centre of the Gallery, and a lower jaw has been added to the cranium, which greatly increases the interest of the specimen. The tusks, which, by compression in the rock, had been squeezed close together, and presented an abnormal appearance, have now been set up wider apart, so as to allow of a sufficient interval for the insertion of the proboscis, as would of necessity have been the case in the living animal.

Turning to Falconer's Palæontological Memoirs[1] (vol. i, p. 20), we find he proposes the following classification of the species of *Mastodon* and *Elephas*, based upon the ridge-formula and structure of the molar teeth. After dividing the Mastodons into Trilophodonts and Tetralophodonts, Falconer proceeds to classify the elephants into three sectional groups, namely: I, *Stegodon*; II, *Loxodon*; III, *Elasmodon*. In the first of these divisions (*Stegodon*), Falconer placed those species which Owen called 'Transitional Mastodons.'

[1] "Palæontological Memoirs and Notes of the late Hugh Falconer, M.D., V.P.R.S., For. Sec. Geol. Soc." (1868), compiled and edited by Chas. Murchison, M.D., F.R.S. Two vols., 8vo (plates).

This group, he tells us, forms the nearest approach to the Mastodons; indeed, Clift gave them the designation of *Mastodon elephantoides*. A fragment of one of the teeth, denuded of its coat of cement, and seen by a naturalist for the first time, would at once be referred to *Mastodon* rather than to *Elephas*. But when the essential characters are analyzed, the species are seen to partake more of the nature of true elephants.

Writing on the characters of the *Stegodons*, Falconer observes: "Sir Proby Cautley and myself have thought we could distinguish four species of *Stegodon*—namely, *S. Cliftii*, *S. bombifrons*, *S. insignis*, and *S. ganesa*."

In his Catalogue of the Fossil Mammals in the British Museum (Natural History), 1886, part iv, p. 88, R. Lydekker writes:—"The third true molars in the type cranium of this species contain ten ridges, and thereby agree with the corresponding teeth of *E. insignis* rather than of *E. bombifrons*, a conclusion confirmed by a second cranium, in which there appear to be either ten or eleven ridges in the same tooth. This close resemblance between the last molar of this form and of *E. insignis* renders it apparently impossible to draw any distinction between the earlier teeth of the two forms, and all such teeth are therefore referred to the latter. Falconer had considerable doubts as to the specific distinctness of the present form, and as the resemblance between the type cranium and the young cranium of *E. insignis* indicates that the two are closely related, it is possible that *E. ganesa* may be the male form of *E. insignis*." "The adult cranium," he adds, "does not differ very widely from the type of *E. indicus*, although the frontal constriction is less marked." This last observation was probably due to the former unnatural position in which the skull of *E. ganesa* was

Figure showing the original position of the skull of *Elephas ganesa* (reduced to $\frac{1}{36}$ nat. size), as formerly mounted in the Geological Gallery of the British Museum (Natural History), after Prof. A. Gaudry's "Les Enchainements du Monde Animal," 8vo, 1878. The present position of the skull is shown in Pl. XIV, Fig. 2.

mounted. Anyone viewing the skull, as now placed in its normal position, i.e. with the grinding surface of the molars upon a nearly horizontal line (Pl. XIV, Fig. 2), and comparing it with the above woodcut (which shows the position of the head as originally set up, and as figured in the "Fauna Antiqua Sivalensis"), cannot fail to be struck by the great change produced in the aspect of the fossil. The cranium in profile, measured from the palate to

the vertex, is seen to be nearly twice as high as it is deep when measured from the nares to the occiput. This brachycephalic character of the skull, producing so elevated and narrow a profile to the head, is greatly accentuated by the addition of the lower jaw to the specimen.

Continuing his observations on the several specimens referred by him to *Elephas ganesa*, Falconer (on p. 80, op. cit.) describes a vertical section of the last upper molar attributed to an undescribed Indian fossil elephant, named *E. ganesa* in this work.[1] "The crown consists of ten principal ridges, with a subordinate 'talon' ridge in front and behind. The anterior seven ridges have their summits worn, the two in front being ground down to the common base of ivory, the tooth having been a considerable time in use.

"The disposition and relative proportions of the ivory, enamel, and cement bear the closest resemblance to those of the corresponding tooth of *E. insignis*" (op. cit., pl. iv, fig. 1), "and the number of ridges agrees" (see also op. cit., vol. i, p. 424). Dr. Falconer adds: "Notwithstanding that the molars agree so closely, the crania are remarkably different in the two forms; that of *E. insignis* is singularly modified, being much compressed on the vertex, so as to bear an analogy to the cranium of *Dinotherium giganteum*; while the head of *E. ganesa* does not differ much from the ordinary type of elephant."

The following description of the large skull of *Elephas ganesa* from the Sewalik Hills, presented by Colonel Baker to the British Museum, is taken from Falconer's "Pal. Memoirs," vol. i, p. 453, being the explanation of pl. xxi of Falconer & Cautley's "Fauna Antiq. Sival." (issued without text): "Large skull with left incisive *in situ*, and fragment of right incisive detached. The incisive alveoli are remarkably elongated, as in *E. primigenius*. The plane of the incisives is continuous with that of the frontal, but with a tendency to obliquity forwards. The skull is very imperfect on the right side. Pl. xxi gives a front view one-fifth of the natural size, and pl. xxii, figs. 1 and 2, gives a lateral and palatal view of the same skull."

The dimensions are as follows (op. cit., p. 454):—Length of cranium from occipital protuberance to the end of the incisive left side (4 feet exactly), 48 in. From occipital condyles to left side, 39 in. From occipital condyles to anterior border of molar alveolus, 25·5 in. Vertical height from condyles to sinciput, 24·5 in. Diameter across the occipital condyles, 9·2 in. Antero-posterior diameter of left condyle, 5·1 in. Transverse diameter of right condyle, 3·85 in. Transverse diameter of occipital foramen, 3 in. Antero-posterior diameter of occipital foramen, 3·1 in. From the surface occipital bulge plane to the anterior entire margin of naso-maxillary sinus, 19·1 in. Semi-diameter of widest part of occipital (making total of occiput 29·2 in.), 14·6 in. Semi-diameter (transverse) of naso-maxillary sinus (entire diameter restored estimated 16 in.), 7·9 in.

[1] "Pal. Mem.," vol. i, p. 80, pl. vi, fig. 1; or "Fauna Antiq. Sival.," pl. iii, fig. 7*a*. Length of tooth, 9·25 inches.

Interval between naso-maxillary sinus and post-orbital margin of frontal, 4·55 in. Mesial width across forehead from post-orbital process to inner margin of incisive left side, 13·1 in. (width of forehead at this part restored, 26·25 in.). From tip of post-orbitary process to surface of occipital, 17·75 in. From tip of incisives outside to post-orbitary process, 30·75 in. Length of incisive to margin of naso-maxillary sinus, 31 in. Depth of zygomatic fossa, 4·25 in. Estimated width of cranium between middle of zygomatic fossæ, 19·5 in. Height from lower margin of auditory foramen to the summit of sinciput, 18 in. Depth or height of cranium from the posterior margin of molar alveolus (back part of palate) to the summit of sinciput, 32 in. Depth from posterior and upper margin of occipital foramen to posterior margin of molar alveolus, 9·5 in. Height of the orbit, 8·78 in. Length of anterior portion of the palate, and from anterior end of molar alveolus to tip of incisive, 16 in. Transverse diameter, left incisive at tip, 11·5 in. (Estimated width of both incisives at tip, 24 in.) Vertical diameter of left incisive at tip, 10·6 in. Vertical height of sub-orbitary foramen, left, 3·85 in. Width of incisive at contraction below sub-orbitary foramen, 10·75 in. Width of incisive sheath at sub-orbitary foramen, 7·5 in. (Estimated width of both incisive sheaths at sub-orbitary foramen, 21·5 in.) Interval between posterior molars, anterior end (width of palate in front), 2·7 in. Interval behind, 3·25 in. Length of right molar (backmost), 11·9 in. Width of right molar in front, 4·05 in. Width of right molar behind, 5 in. Vertical height from posterior outer margin of molar alveolus to post-orbitary process, 21 in. Interval between outer surfaces of the molars at fifth ridge from front, 12·6 in. Antero-posterior diameter, auditory foramen, 1·15 in. Transverse diameter, auditory foramen, 1 in. Estimated height of occiput at restoration from lower surface of condyles to sinciput, 24·5 in. Length of left tusk outside the incisive sheath, measured along the lower surface, 10 ft. 6 in. Length of left tusk inside the sheath, 2 ft. 3 in. to 2 ft. 4 in. Estimated total length, 12 ft. 9 in. Total length of head from occipital protuberance to tip of tusk, 4 ft. + 10 ft. 6 in. = $14\frac{1}{2}$ feet. Length of right tusk, 10 ft. $8\frac{1}{2}$ in. Interval between the tusks at emergence from incisive sheath, 6 in. Interval between the tusks at nearest approximation, at $3\frac{1}{2}$ feet from incisive, 3·5 in. Divergence at tips, 5 ft. $3\frac{1}{2}$ in. as restored. Height of versed sine of curve from tip to incisive border, right side, 23 in. Height of versed sine of curve from tip to incisive border, left side, 23 in. Vertical diameter left tusk (14 in. from base) where greatest, 9 in. Transverse diameter, left tusk, at ditto, 7·9 in. Girth of left tusk at ditto, 26 in.

Referring to the molar teeth of *E. ganesa*, Falconer writes (of pl. iii, fig. 7*b*, "Fauna Antiqua Sivalensis") on p. 81, "Pal. Memoirs":—This figure "shows a vertical section of one of the posterior molars of the lower jaw, which we infer to belong to the same species. A small portion of the anterior end of the crown has been broken off; but the presence of the anterior fang proves that the section includes the whole length of the tooth except the first ridge,

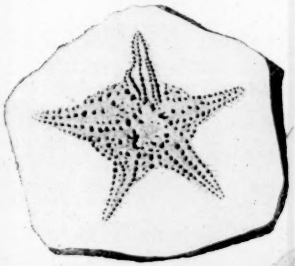


Fig. 2*a*.

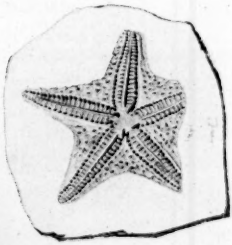


Fig. 2*b*.

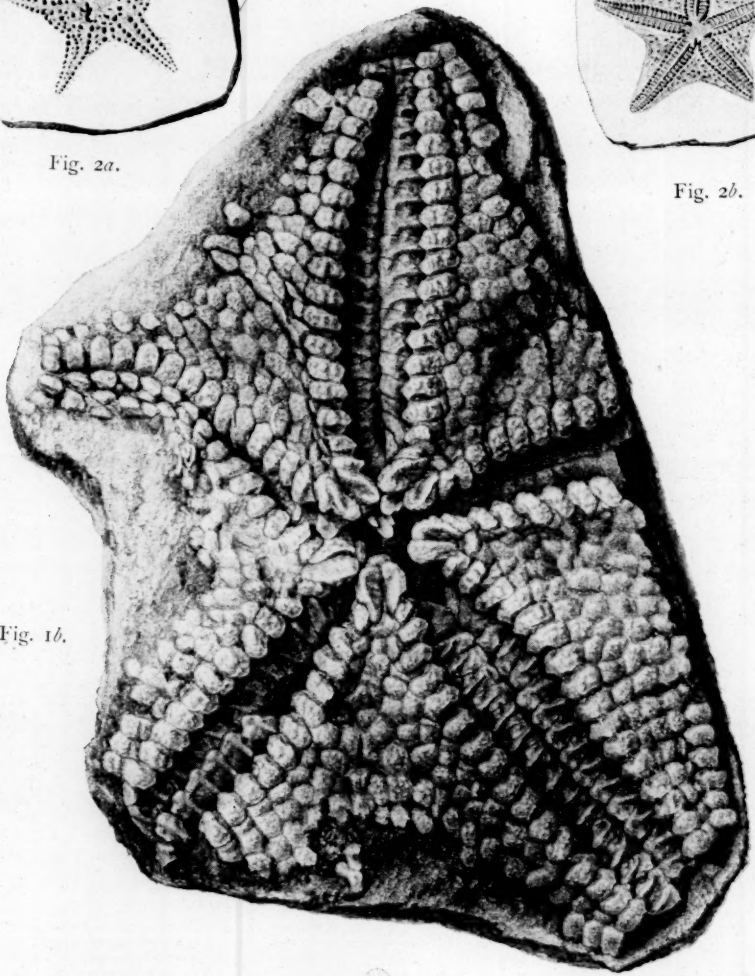


Fig. 1*b*.

Fig. 1*a*.

Figs. 1*a*, *b*, *Lindstromaster antiqua*, and Figs. 2*a*, *b*, *Palæasterina Bonneyi*.

Fig. 1, from a drawing of the type-specimen by Geo. Liljevall.
,, 2, ,, ,, by J. W. Lowry.

the posterior end being entire. It appears to have consisted of eight principal ridges, with a 'talon' ridge behind and a subordinate ridge in front. Five of the ridges have been in use, the anterior two in the section being worn down close to the common base of ivory, while the three last ridges are entire. Like the upper molar of *E. ganesa* (already referred to), it bears a close resemblance to the corresponding inferior tooth of *E. insignis* (pl. iv, fig. 1, op. cit.) in the form of the ridges, thickness of enamel, and proportion of cement. This specimen measures about 7½ inches in length (see also op. cit., vol. i, p. 424)." In the same work,[1] he describes (pl. XX A, figs. 1 and 1*a*) a "Lower jaw with first and second true molars, of *Elephas ganesa* (Falc. & Caut.), from the Sewalik Hills. Proved to be so by fig. 2. A most remarkable jaw, very high in front and with very divergent rami behind; diastemal edges very sharp; two outer mentary foramina on right side. The front tooth much worn; has five ridges and a heel; the last tooth has eight ridges." Falconer adds, "Nothing else like this in the collection, B.M."

Extreme length of jaw, 18·5 in. Height at alveolus, 8·5 in. Width of jaw in front, 4 in. Width of jaw behind, 5·8 in.! Length of front tooth, 5·1 in. Width, 2·7 in. Length of last tooth, 9·3 in. Width, 3·2 in.

Figs. 2 and 2*a*.—*Elephas ganesa*. Portion of lower jaw with left penultimate lower molar. The jaw in this specimen is also very high and narrow in front and low behind. The tooth has seven ridges and a heel. Behind it is seen a portion of the last molar. B.M. Length of fragment, 14·5 in. Height at alveolus, 8·3 in. Height behind, 5·8 in. Width in front, 3·3 in. Width behind, 6·6 in. Length of molar, 9·2 in. Width at back, 3 in.

EXPLANATION OF PLATE XIV.

FIGS. 1 and 2.—*Elephas ganesa*, Falc. & Caut. Fig. 1, front view, and Fig. 2, profile, of skull and tusks, as now exhibited in the Geological Gallery of the British Museum (Natural History), Cromwell Road. The specimen measures 14½ feet in length. From the Pliocene of the Sewalik Hills, India. Presented by General Sir William Erskine Baker, K.C.B., 1848.

II. — On *Lindstromaster* and the Classification of the Palæasterids.

By J. W. Gregory, D.Sc., F.G.S.

(PLATE XVI.)

THE classification of the Palæozoic starfishes has long been in chaos. The earlier palæontologists, who founded most of the known genera, made no attempt at a general classification or to indicate the relations between the Palæozoic and existing representatives of the Asteroidea. The first step towards progress was Bronn's[2] division of the extinct genera into three groups—the Ophiurasteriæ (which may be left out of account as Ophiuroidea), the Encrinasteriæ, and the Asteriæ veræ. The last two groups have

[1] Falconer & Cautley's "Fauna Antiqua Sivalensis" (the figures of which are described in Falconer's "Pal. Memoirs," 1868, vol. i, p. 452).

[2] H. G. Bronn: Classen und Ord. Thierreichs, vol. ii (1860), pp. 287–8.

been accepted by most palæontologists who have referred to the group. Thus they were adopted by von Zittel,[1] who simply redefined the genera, and by Stürtz,[2] whose important papers included the first attempt at a formal classification.

The character on which Bronn's groups were based is the arrangement of the ambulacral ossicles. In the Encrinasteriæ (or Palæasteroidea as they are sometimes called) the ambulacral ossicles are said to be alternate, whereas in the Asteriæ veræ or Euasteroidea they are said to be opposite in position. The alternation of the ambulacral ossicles is no doubt the primitive arrangement; and it is a character of great importance among ophiurids, for so long as it was retained the union of the pairs of ambulacral ossicles into vertebral ossicles was impossible. But among the asterids the character is not essential; for the ambulacral ossicles in each pair never fuse, but remain as independent bars, meeting at their narrow ends. The alternation may at any time result from growth pressure. In some starfish the ambulacral ossicles in one part of a ray may be alternate, while in another part they may be opposite. The character is, moreover, difficult to use, as in some asterids the two series of ambulacral ossicles appear to have a certain amount of movement past one another during the lateral bending of the arm.

The alternation or opposition of the ambulacral ossicles is therefore not a good character for the primary subdivision of the Asteroidea. That the older asterids had alternate ambulacrals is only to be expected, for that was naturally the primitive arrangement. It was gradually lost as the ambulacrals became reduced in size and the arms more flexible. The artificial nature of the divisions based on this character is shown by the action of Stürtz, who divided several of his families into two parts, and placed one part in the Encrinasteriæ and the other part in the Asteriæ (or Stelleridæ) veræ. Thus his family Palæechinasteridæ comprised the genera *Echinasterella* and *Palasteriscus*. The former he placed in the Encrinasteriæ and the latter in the Asteriæ veræ.

Nor is it possible to use the alternation or opposition of the ambulacral ossicles as a basis for the divisions Palæasteroidea and Euasteroidea, for Bronn, von Zittel,[3] and Nicholson[4] have correctly included some of the Palæozoic asterids in the Asteriæ veræ.

Bronn's classification appears, therefore, neither morphologically nor historically justifiable, and a more convenient system is desirable. In 1889 Sladen[5] founded the two groups, the Phanerozonia for asterids having large marginal plates and the dermal

[1] K. von Zittel: Handb. Palaeont., vol. i (1879), pp. 451–4.

[2] B. Stürtz, "Neuer Beitr. Kennt. palaeoz. Seesterne": Palæontogr., vol. xxxvi (1890), pp. 246–7. "Über verst. und leb. Seest.": Verh. naturh. Ver. preuss. Rheinl., ser. 5, vol. v (1893), pp. 76–7.

[3] K. von Zittel: Handb. Palaeont, vol. i (1879), p. 454.

[4] H. A. Nicholson: Man. Pal., vol. i (1889), p. 397.

[5] W. P. Sladen, "Report on Asteroidea collected by 'Challenger'": Rep. Chall. Exp., Zool., vol. xxx, pp. xxviii and xxxiv.

branchiæ confined to the abactinal surface, and the Cryptozonia for asterids having the marginal plates rudimentary or absent and the dermal branchiæ not confined to the abactinal surface. Sladen founded these divisions only as orders of Euasteroidea. But Stürtz in 1893 subdivided the other section, or Encrinasteriæ—with which the group of Palæasteroidea must be entirely or mainly identical—also into Phanerozonia and Cryptozonia; and then in turn he subdivided the Stelleridæ veræ in the same way. It seems to me possible to extend still further Stürtz's extension of Sladen's classification, and to divide the Asteroidea primarily into Phanerozonia and Cryptozonia, abandoning Bronn's classification altogether.

It is true that M. Perrier[1] has criticized the fundamental principle of Mr. Sladen's system, which is not free from difficulties; but his alternative plan[2] is certainly less helpful in the study of fossil starfish.

About three years ago I rashly undertook to prepare a synopsis of the known Asteroidea, which had to be completed by September, 1896. I accordingly endeavoured to bring the fossil and recent genera into line by the above suggested extension of Sladen's system. The classification is necessarily provisional, and was prepared in reliance on Bacon's maxim that truth more often springs from error than from ignorance. I hoped that a clear series of definite family diagnoses would show the gaps in our knowledge of the anatomy of Palæozoic starfish, and thus help toward something better. This classification having been prepared, I delayed the publication of this paper until the diagnoses were available for reference.

Some years back, owing to the kindness of the late Dr. Johnstrup of Copenhagen, I received, through the agency of Professor Lindström and my colleague Mr. F. A. Bather, the loan of the type-specimen of Hisinger's *Asterias antiqua*, which is now preserved in the Mineralogical Museum of Copenhagen. As the original figure was diagrammatic and indefinite, the specimen had been redrawn by Mr. Georg Liljevall of Stockholm, with the scientific accuracy and artistic skill for which his work is famous. This drawing, which is the property of the Riksmuseum in Stockholm, has been kindly lent me by Professor Lindström, who has also permitted the accompanying plate to be prepared from it. For Professor Lindström's indulgence in allowing me to retain the drawing—I am ashamed to say for how long—I owe him my sincerest thanks.

The history of this species is simple. It was founded by Hisinger[3] in 1837, and assigned to the genus *Asterias*. In 1848 it was transferred to *Palmipes* by Edward Forbes, owing to a mistake as to its geological age, which he regarded as Cretaceous. Salter in 1857 removed the species to the genus *Palæasterina*, which he apparently considered an ally of *Palmipes*; for he remarked

[1] Ed. Perrier, "Contrib. ét. Stell. Atl. Nord": Result. Camp. Sci. Albert I., fasc. xi (1896), pp. 10–14.

[2] Ibid., pp. 7, 15.

[3] The references are given in the synonymy on p. 347.

regarding the type species of the genus, that Forbes "would have referred it, and with it the whole group, *to their true position* near *Asteriscus* (*Palmipes*)." Since that date the species has always been included in *Palæasterina*, as by Lindström, who in 1888 published a synonymy of the species.

It is, however, quite clear that the species belongs to a genus distinct from *Palæasterina*. I therefore propose to call it *Lindstromaster*, as it comes from the beds which will always be associated with Professor Lindström's name. The word is open to criticism as being a mongrel composed of Swedish and Greek. But so long as such terms as glaciology are in current scientific use, and so long as we give animals such names as *Nautilus imperialis*—a mixture of good Greek and bad Latin—other convenient mongrel terms may be tolerated. And *Lindstromaster* is certainly convenient. It not only shows at once that the animal is a starfish, but by reference to the name of the distinguished authority on the Swedish Silurian fauna suggests the age and country in which the genus lived. The name has many precedents, as, for instance, *Salteraster*, which is as hybrid etymologically and as instructive palæontologically.

To illustrate the affinities of *Lindstromaster* and simplify its description it will be advisable to include diagnoses of the Palæasteridæ and Palæasterinidæ. The present opportunity is also taken for the description of two new species and the institution of three other new genera.

Class STELLEROIDEA.

Subclass ASTEROIDEA.

Order 1. PHANEROZONIA.

Family 1. PALÆASTERIDÆ.

DIAGNOSIS.

Phanerozonia with the ambulacral ossicles all or mostly alternate in position. The madreporite is abactinal, and the oral armature adambulacral. The skeleton of the abactinal surface and interradial areas is tessellate. Marginal plates large.

Subfamily 1. PALÆASTERINÆ.

DIAGNOSIS.

Palæasteridæ with the ambulacral ossicles definitely alternate. The rays are usually long and sharply marked off from the disc, which is always small, with small interradial areas.

1. PALÆASTER, Hall, 1852.

Pal. New York, vol. ii, p. 247 (*non* Salter, Trautschold, De Koninck, etc.).

TYPE SPECIES.—*P. Niagarensis*, Hall, 1852. Op. cit., p. 247, pl. li, figs. 21–23. Silurian—Niagara Series: Lockport, New York.

PALÆASTER CARACTACI, Salter MS.

DIAGNOSIS.

A small species with $R : r$ as $12 : 3\frac{1}{2}$. The arms are therefore long. They taper gradually. The infra-marginal plates number

11 or 12 on each side of each ray. They are large, and the exterior side is tumid.

On the abactinal surface of each ray there appear to be three rows of small plates, of which those of the median series are the largest.

The madreporite is large, and placed close by one of the interradial angles.

DIMENSIONS.

	B.M., 48,206.
R	12 mm.
r	3·5 ,,
Width of arm at the base	3·5 ,,

DISTRIBUTION.

Caradoc Sandstone. ? Soudley Quarry, Church Stretton. The specimen on which the above diagnosis is based is contained in a small nodule, and is labelled from the Soudley Quarry. Mr. R. A. Buddacombe has, however, expressed doubt as to the exact correctness of this locality. The specimen is in the British Museum Collection (No. 48,206).

AFFINITIES.

This species was recorded by Salter[1] in 1865, but I am not aware that any description has been published. R. Etheridge, jun., and Nicholson remarked that the species is a true *Palæaster*, an opinion no doubt based on the specimen here described (British Museum, No. 48,206).

The nearest ally of this species is *P. matutina* (Hall),[2] from the Trenton Limestone in the State of New York, which has a single row of large plates filling up the space between the marginals on the abactinal side.

2. ARGASTER, Hall, 1867.

Note on *Palæaster*, 20th Rep. Reg. Univ. New York, p. 287 ; and Nicholson & Etheridge, jun., Sil. Foss. Girvan, 1880, p. 322.

TYPE SPECIES.—*Asterias antiqua*, Troost, 1835. Trans. Geol. Soc. Pennsyl., vol. i, p. 232, pl. x, fig. 9.

? 3. TETRASTER, Etheridge, jun., & Nicholson, 1880.

Sil. Foss. Girvan, p. 324.

TYPE SPECIES.—*Tetraster Wyville-Thomsoni*, Eth., jun., & Nich., 1880. Op. cit., p. 324, pl. xxi, figs. 1–8.

4. PETRASTER, Billings, 1858.

Dec. Geol. Surv. Canada, No. iii, p. 80.

TYPE SPECIES.—*Palæasterina rigidus*, Billings, 1856. Rep. Geol. Surv. Canada, 1856, p. 291. *Petraster rigidus*, Dec. Geol. Surv. Canada, 1858, vol. iii, p. 80, pl. x, fig. 3. Trenton Limestone: Ottawa.

5. MONASTER, Etheridge, jun., *pars*, 1892.

Mon. Carb. Invert. New South Wales, pt. ii, pp. 70–1.

TYPE SPECIES.—*Palæaster* (*Monaster*) *giganteus*, R. Etheridge, jun., 1892. Op. cit., p. 74, pl. xii.

[1] *Asterias matutina*, Hall, 1847 : Pal. New York, vol. i, p. 91, pl. xxix, fig. 5. *Palæaster matutina*, Hall, 1867 : 20th Reg. Rep., p. 283, pl. ix, fig. 2.

[2] Salter : Cat. Foss. Mus. Pract. Geol., p. 30.

This is the third species referred by Mr. R. Etheridge, jun., to *Monaster*, but he does not definitely choose any one of the three as the type; the name having been suggested "from the one or single row of adambulacral plates on each side of an ambulacral avenue." *M. giganteus* is the best type; for by adambulacral plates Etheridge no doubt means all the actinal plates except the ambulacrals, as the true adambulacrals are always uniserial. *M. Strutchburii*, Eth., jun., is also a *Monaster*, but *M. Clarkei* is referred to a new genus (p. 353).

Subfamily 2. XENASTERINÆ.

DIAGNOSIS.

Palæasteridæ with the general characters of the Palæasterinæ, but with most of the ambulacral ossicles opposite.

XENASTER, Simonowitsch, 1871.

"Aster. rhein. Grauwacke": Sitz. k. Akad. Wiss. Wien, vol. lxiv, p. 88.

TYPE SPECIES.—*Xenaster margaritatus*. Op. cit., p. 88, pls. i and ii. Devonian: Germany.

AFFINITIES.

This genus has been assigned by von Zittel and Nicholson to the Asteriæ veræ, owing to the opposite position of the ambulacral ossicles, which is the main character of the subfamily to which the genus is here referred. The interradial areas are larger than in typical species of Palæasteridæ, at least in the type of *Xenaster*; but *X. simplex*, Sim., which ought no doubt to be made the type of a new genus, agrees closely with characteristic forms of *Palæaster*, except in the opposite position of the ambulacral ossicles. The value of this character is doubtful since in Simonowitsch's figure of *X. margaritatus* on pl. ii, fig. 3, while some of the adambulacrals are opposite, others are alternate; probably the ambulacral ossicles would vary in the same way. If it should appear on re-examination of the types of the genus that Simonowitsch's figures (e.g., his pl. i, fig. 1*b*; pl. iii, fig. 1*b*) are incorrect, then the subfamily would be unnecessary, and *Xenaster simplex* might enter *Palæaster*, and *X. margaritatus* take rank close to *Palæaster encharis*, Hall, for which otherwise a new genus is wanted.

Subfamily 3. LINDSTROMASTERINÆ.

DIAGNOSIS.

Palæasteridæ with alternate ambulacral ossicles, a large disc covered with tessellate plates, and large interradial areas.

1. LINDSTROMASTER, nov. gen.

DIAGNOSIS.

Palæasterinidæ with flat pentagonal disc and five short blunt rays. The plates of the disc are large, polygonal, tuberculate, and crowded into a close tessellate pavement, which completely covers the interradial areas.

Marginal plates well developed and conspicuous, and but slightly smaller than the adambulacrals. Both supra- and infra-marginals appear to be present.

The abactinal furrows are large and subpetaloid. They are bounded by large, tuberculate adambulacral plates. The ambulacral plates are boot-shaped. The pores for the podia are large, and occur on the suture between the adambulacrals and ambulacrals.

The adambulacral elements in the oral armature are prominent, and consist of five pairs of subtriangular plates.

TYPE SPECIES. — *Asterias antiqua*, Hisinger, 1837. Silurian : Gotland.

LINDSTROMASTER ANTIQUA (Hisinger), 1837. Pl. XVI, Fig. 1.

SYNONYMY.

Asterias antiqua, Hisinger, 1837 : Leth. Svec., p. 89, pl. xxvi, fig. 6.
,, ,, Hisinger, 1840 : Anteckningar, pt. vii, p. 64.
,, ,, Bronn, 1848 : Ind. Pal., Nomencl., p. 120.
Palmipes ,, Forbes, 1848, "Aster. foss. Brit." : Mem. Geol. Surv., vol. ii, pt. 2, p. 481.
,, ,, Lindström, 1867 : Nom. foss. Sil. Gotl., p. 26.
Palæasterina antiqua, Salter, 1857, "New Pal. Starfishes" : Ann. Mag. Nat. Hist., ser. 2, vol. xx (1857), p. 327.
,, ,, Woodward, 1869 : *Eucladia*, GEOL. MAG., Dec. I, Vol. VI, p. 244.
,, ,, Lindström, 1885 : List foss. Gotland, p. 14.
,, ,, Lindström, 1888 : List. foss. Faunas Swed., pt. ii, p. 16.
,, ,, Lindström, 1888 : Schichtenf. Sil. Gotl., N. Jahrb., 1888, vol. i, p. 157.
,, ,, Stürtz, 1893, "Verst. und leb. Seesterne" : Verh. Nat. Ver. preuss. Rheinl., p. 44.
Asteriscus antiquus, Pictet, 1857 : Traité Pal., vol. iv, p. 267, pl. xcviii, fig. 4.

DIAGNOSIS.

Disc small, with the ratio of $R : r$ as 18 : 11.

The interradial areas (and the whole 'squelette ventro-lateral' of Perrier) are wide, and include 9 or 10 plates in width across the radius to the interradial angle.

The adambulacral plates number about 20 in each series.

DIMENSIONS.

	Hisinger's figure.	Measurements from the specimen.
R	18 mm.	18 mm.
r	13 ,,	11 ,,
Maximum width of ambulacral furrow	3 ,,	3 ,,

DISTRIBUTION.

Bed *C*, corresponding to the Wenlock Shale, Gotland.

FIGURES.

Pl. XVI, Fig. 1. Actinal surface of the type-specimen, Angelin Coll., Mineralogical Museum, Copenhagen. Fig. 1*a*, the outline of the specimen, nat. size ; Fig. 1*b*, the same, × 4 dia.

2. URANASTER, nov. gen.

[From Uranus, the grandfather of Pluto ; the starfish resembles the living genus *Plutonaster*.]

DIAGNOSIS.

Lindstromasterinæ with a large disc and five long, gradually tapering arms.

The marginal plates are large. On the abactinal surface they are separated by numerous closely fitting plates, with convex upper surfaces, so that they appear tubercular. These intermediate abactinal plates are arranged in alternate, transverse rows. No carinal abactinal plates.

Ambulacral plates traversed by strong transverse ridge. Adambulacral plates thick and tubercular.

Type Species.—*Palæasterina Kinahani*, Baily, 1879. Mem. Geol. Surv. Ireland, Sheet Nos. 169, 170, 180, 181, p. 58, fig. 6; p. 59.

Affinities.

The genus differs from *Lindstromaster* by its long rays and transverse rows of abactinal intermediate plates.

Uranaster Kinahani (Baily), 1879.

Diagnosis.

Medium-sized starfish, with *R* of about 30 mm. and *r* of about 7 mm. The arms are 8 mm. across at the base.

Marginal plates elongated in the direction of the arm; about 30 supramarginals on each side of each ray.

Abactinal intramarginal plates consist of an outer row of large submarginal plates, alternating with the marginals; small plates sometimes occur in the angle between these plates and the marginals. Within the submarginal plates there is on each side of the ray a row of three or four small tubercular plates. There is no carinal series.

The plates in the actinal interradial areas are irregular and polygonal.

The actinal furrow was apparently narrow, tapering gradually, and deep.

Distribution.

Caradoc: Wexford. The above diagnosis is based on specimen E 194 in the British Museum; it was collected near Bannon.

Family 2. PALÆASTERINIDÆ.

Diagnosis.

Phanerozonia with the ambulacral ossicles alternate, the oral armature adambulacral, and the madreporite abactinal. The disc is large and pentagonal, and the rays are short and separated by large interradial areas. The marginal plates are smaller than the adambulacral plates.

Affinities.

The family agrees with the Palæasteridæ in the three first characters stated; but differs from it by the shortness of the rays and large size of the disc, and by the less development of the marginal plates. The family differs from the Aspidosomatidæ by the fact that the rays are never petaloid, and by the absence of the abactinal depressions between the marginal plates and the longitudinal series of abactinal arm plates.

1. PALÆASTERINA, McCoy, 1851.

SYNONYMY.[1]

Palæasterina, McCoy, 1851 : Brit. Palaeoz. Foss., fasc. i, p. 59.
,, *pars*, Salter, 1857, "New Pal. Starfishes" : Ann. Mag. Nat. Hist., ser. 2, vol. xx, pp. 324, 327.
,, *pars*, Billings, 1858 : Dec. Geol. Surv. Canada, No. iii, p. 76.
,, *pars*, Salter, 1859 : in Murchison, "Siluria," 3rd ed., p. 248.
non ,, Dana, 1863, "Note foss. Echinod." : Amer. Journ. Sci., ser. 2, vol. xxxv, p. 295.
non ,, Hicks, 1873, "Tremadoc St. Dav." : Quart. Journ. Geol. Soc., vol. xxix, p. 51, pl. iv, figs. 21–23.
non ,, Baily, 1879 : Mem. Geol. Surv. Ireland, No. 169, etc., p. 58.
,, von Zittel, 1879 : Handb. Palaeont., vol. i, p. 453.
non ,, Etheridge, 1881 : Pres. Add., Quart. Journ. Geol. Soc., vol. xxxvii, Proc., p. 92.
,, *pars*, De la Touche, 1884 : Handb. Geol. Shrops., p. 34.
non ,, Stürtz, 1886, "Beitr. pal. Seest." : Palæontogr., vol. xxxii, p. 96.
,, Stürtz, 1890, "Neu. Beitr. pal. Seest." : ibid., vol. xxxvi, p. 226.
,, *pars*, Stürtz, 1893, "Ueber verst. und leb. Seest." : Verh. naturh. Ver. preuss. Rheinl., ser. 5, vol. x, p. 43.
Uraster, *pars*, Forbes, 1848, "Aster. foss. Brit." : Mem. Geol. Surv., p. 463.
,, ,, Forbes, 1849 : Dec. Geol. Surv., No. i, pl. i.

DIAGNOSIS.

Palæasterinidæ with the rays shortly produced but distinctly marked off from the disc. *R* is about twice as great as *r*.

The skeletal plates are large and thick, but not packed into a tessellate pavement, the separate plates on the disc being rounded and isolated. There is a circle of five pairs of plates round the centre of the abactinal side; from this circle series of four longitudinal rows of plates pass outward down each ray. The plates of the longitudinal series become crowded and subpolygonal at the distal end of the rays.

On the actinal side the interbrachial areas are covered with isolated, rounded, or subangular plates, bearing spines. The marginal plates are small and usually bear small spines. The presence of supramarginals is doubtful.

The adambulacral ossicles are boot-shaped, and the ambulacral groove is bordered by a series of large adambulacrals.

TYPE SPECIES.—*Palæasterina primæva* (Forbes), 1848.[2] Mem. Geol. Surv., vol. ii, pt. 2, p. 463 ; 1849, Dec. Geol. Surv., dec. i, pl. i, fig. 2. Ludlow Series : Underbarrow, Westmoreland.

PALÆASTERINA BONNEYI, n.sp. Pl. XVI, Figs. 2*a*, *b*.

DIAGNOSIS.

Rays short and blunt, tapering regularly ; disc rounded or subpentagonal. The ratio of *R* to *r* is 2 : 1.

On the abactinal surface there are three longitudinal series of large plates, crowded distally, but separated by areas bearing smaller plates in the disc.

[1] The references included in the above list show some of the limitations to which the genus must submit.

[2] Salter and J. de C. Sowerby in 1843 recorded an asterid from the Arenig beds as *Asterias primæva*, but apparently it was never described (Quart. Journ. Geol. Soc., vol. i, p. 8, and table i, opposite p. 21).

About 25 large, oblong adambulacral plates on each side of each ray. The adambulacrals bear small tufts of about three spines, and single spines occur on the plates of the actinal intermediate areas, which plates are numerous.

DISTRIBUTION.

Ludlow Shales: Leintwardine, Shropshire.

FIGURES.

Pl. XVI, Figs. 2*a* and *b*. Abactinal and actinal views of specimens in the Geological Survey Collection.

Fig. 1, abactinal surface of part of the disc and one ray, × 3 dia. Fig. 2, actinal view of a ray, × 4 dia. Figs. 3*a* and *b*, abactinal and actinal views of distal part of one ray.

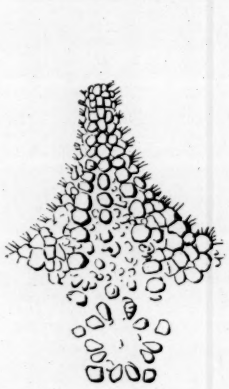


FIG. 1.

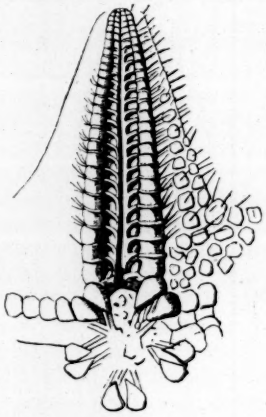


FIG. 2.

FIG. 3*a*.

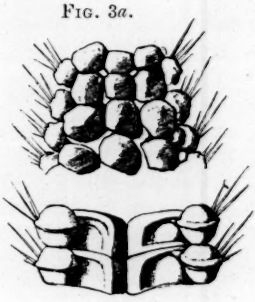


FIG. 3*b*.

Palæasterina Bonneyi. Ludlow Shales: Leintwardine.

FIG. 1. — Abactinal surface of one ray, × 3 dia. FIG. 2. — Actinal surface, × 4 dia. FIGS. 3*a* and *b*.—Abactinal and actinal views of distal end of ray.

AFFINITIES.

This species has hitherto been included in *P. primæva*, the type species of the genus, from which it differs by having shorter and blunter rays, more numerous actinal interbrachial plates, and more adambulacral plates in each series; the character of the abactinal ray plates is also different in the species, the longitudinal series being widely separated at the proximal end of the rays in *P. Bonneyi*.

The species is of interest, as the structure is better preserved than in the type of the genus, and thus we are largely dependent upon it for our knowledge of the generic characters. These are well shown in the accompanying illustrations, which are prepared from the proofs of some unpublished drawings by J. W. Lowry.

2. SCHŒNASTER, Meek & Worthen, 1860.

Palæasterina, subgenus *Schœnaster*, Meek & Worthen, 1860: Proc. Acad. Nat. Sci. Phil., 1860, p. 449; and 1860, Geol. Surv. Ill., Palæont., vol. ii, p. 277.

TYPE SPECIES. — *Palæasterina* (*Schœnaster*) *fimbriata*, Meek & Worthen, 1860. Op. cit., p. 449; and 1866, op. cit., p. 278, pl. xix, fig. 7. Sub-Carboniferous: Illinois.

3. SCHUCHERTIA, nov. gen.

DIAGNOSIS.

Palæasterinidæ with tessellate exoskeleton; the rays are short and the general shape is pentagonal. $R : r$ as 2 : 1. Interradial plates numerous, polygonal. Adambulacral plates large and hexagonal. Ambulacral furrow tapering uniformly toward the distal end.

TYPE SPECIES.—*Palæasterina stellata*, Billings, 1858. Dec. Geol. Surv. Canada, No. iii, p. 76, pl. ix, fig. 1. Trenton Limestone: Ottawa.

AFFINITIES.

Allied to *Palæasterina* by the general form of the body and the absence of the marginal plates. Billings clearly doubted whether the fossil could be left in *Palæasterina*, and he noticed the absence of the spines so conspicuous in the typical species of that genus. The general appearance of the species resembles *Lindstromaster*, from which it differs by the smallness of the marginal plates.

Family 3. ASPIDOSOMATIDÆ.

DIAGNOSIS.

Phanerozonia with alternate ambulacral ossicles, large marginal ossicles, and extensive depressed interradial areas. Rays massive, petaloid, subpetaloid, or tapering.

1. ASPIDOSOMA, Goldfuss, 1848.

"Ein Seestern aus der Grauwacke": Verh. naturh. Ver. preuss. Rheinl., vol. v, pp. 145–6, pl. v.

TYPE SPECIES.—*Aspidosoma Arnoldi*, Goldfuss, 1848. Op. cit. Lower Devonian: Germany.

2. PALÆOSTELLA, Stürtz, 1890.

"Neu. Beitr. palaeoz. Seest.": Palæontogr., vol. xxxvi, p. 230.

TYPE SPECIES.—*Palæostella solida*, Stürtz, 1890. Op. cit., p. 230, pl. xxxi, figs. 42, 43. "Ueber verst. und leb. Seest.": Verh. naturh. Ver. preuss. Rheinl., ser. 5, vol. x, p. 42, pl. i, figs. 6–8. Lower Devonian: Germany.

3. TRICHASTEROPSIS, Eck, 1879.

"Bemerk. zu Pohlig üb. Aspidura": Zeit. deut. geol. Ges., vol. xxxi, pp. 45, 265.

TYPE SPECIES.—*Asterias cilicia*, Quenstedt, 1852. Handb. Petref., p. 596, pl. li, figs. 23, 24. *Trichasteropsis cilicia*, Eck, 1879. Op. cit., pp. 43, 265, pl. iv, fig. 3. Muschelkalk: Crailsheim.

Family 4. TÆNIASTERIDÆ.

DIAGNOSIS.

Phanerozonia with alternate ambulacral ossicles. There is neither disc nor interbrachial area. Large marginal plates, of which the inframarginals act as the adambulacral ossicles. Rays long; petaloid or tapering gradually.

1. TÆNIASTER, Billings, 1858.

Dec. Geol. Surv. Canada, No. iii, p. 80.

TYPE SPECIES.—*Tæniaster spinosus*, Billings, 1858. Op. cit., p. 81, pl. x, fig. 3. Ordovician: Canada. Not *Tæniaster cylindrus*,

Billings (op. cit., p. 81, pl. x, fig. 4), which has been made the type of a genus of Ophiurids — *Tæniura*. (Gregory, "Classif. Palæoz. Ophiur.": Proc. Zool. Soc., 1896, p. 1,035.)

AFFINITIES.

The Tæniasteridæ are possibly nearly allied to the Stichasteridæ, which Sladen includes in the Cryptozonia. They are provisionally left in the Phanerozonia, until the character of the adambulacral plates can be definitely determined. The family is intermediate between the typical Phanerozonia and Cryptozonia.

?2. STENASTER, Billings, 1858.

Op. cit., p. 17.

TYPE SPECIES.—*Stenaster Salteri*, Billings, 1858. Op. cit, p. 78, pl. x, fig. 1. Ordovician: Canada. *Non S. pulchellus*, Billings (op. cit., p. 79, pl. x, fig. 2); *nec S. confluens*, Trautschold, Kalkbr. Mjatsch., pp. 109, 110, pl. xiii, fig. 5.

3. URASTERELLA, McCoy, 1851.

Brit. Palæoz. Foss., fasc. i, p. 59.

TYPE SPECIES. — *Uraster Ruthveni*, Forbes, 1848. "Brit. Foss. Aster.": Mem. Geol. Surv., vol. ii, pt. 2, p. 463. Silurian: Westmoreland.

AFFINITIES.

This genus includes the *Stenaster pulchellus*, Billings (op. cit., p. 79, pl. x, fig. 2). It has often been treated as synonymous with *Stenaster*, or merged in *Palæaster*. Thus Salter,[1] both in 1857 and 1873, included the type species of *Urasterella* and *U. hirudo* (Forbes) in *Palæaster*, whereas in 1859 he[2] included the latter in *Palæasterina*. In the former proposal he has been followed by most English authors, as, e.g., Etheridge,[3] De la Touche,[4] and Woods.[5]

4. PROTASTERACANTHION, Stürtz, 1886.

"Beitr. palaeoz. Seest.": Palæontogr., vol. xxxii, p. 90.

TYPE SPECIES.—*Protasteracanthion primus*, Stürtz, 1886. Op. cit., p. 90, pl. xi, fig. 3. Lower Devonian: Germany.

5. SALTERASTER, Stürtz, 1893.

"Ueber verst. und leb. Seest.": Verh. naturh. Ver. preuss. Rheinl., ser. 5, vol. x, p. 42.

TYPE SPECIES. — *Palæaster asperrimus*, Salter, 1857. New Palæoz. Starf.: Ann. Mag. Nat. Hist., ser. 2, vol. xx, p. 325, pl. ix, fig. 1. Ordovician: near Welshpool, N. Wales.

Order 2. CRYPTOZONIA.

Family LEPIDASTERIDÆ.

DIAGNOSIS.

Cryptozonia which are heavily plated, but in which there are no

[1] J. W. Salter, "New Palæoz. Starfishes": Ann. Mag. Nat. Hist., ser. 2, vol. xx (1857), pp. 325, 326. Also Cat. Cambr. and Sil. Foss. Cambridge, 1873, p. 163.

[2] In Murchison's "Siluria," 3rd ed., p. 248, fig. 56, No. 2.

[3] R. Etheridge: Pres. Add., Quart. Journ. Geol. Soc., vol. xxxvii (1881), Proc., p. 173.

[4] De la Touche: Handb. Geol. Shrops., p. 34.

[5] H. Woods: Cat. Type Foss. Woodw. Mus., p. 35.

special marginal plates. The ambulacral ossicles are alternate (or possibly sometimes opposite). The disc is large, and the rays short, thick, and blunt or clavate. There are no lateral spines. The abactinal plates are granular and closely set.

1. LEPIDASTER, Forbes, 1850.

Dec. Geol. Surv., No. iii, pl. i.

TYPE SPECIES. — *L. Grayi*, Forbes, 1850. Op. cit. Wenlock Limestone: Dudley.

2. ETHERIDGASTER, nov. gen.

DIAGNOSIS.

Lepidasteridæ with five clavate arms. The arms are covered abactinally by three rows of alternating, hexagonal plates. The abactinal surface of the rays is occupied by the broad adambulacral ossicles. Ambulacral ossicles opposite (*fide* De Koninck).

TYPE SPECIES.—*Palæaster Clarkei*, De Koninck, 1877. Foss. Pal. Nouv. Galles des Sud., pt. iii, p. 166, pl. vii, figs. 6 and 6*a*. *Palæaster* (*Monaster*) *Clarkei*, R. Etheridge, jun., 1892. Mon. Carb. Invert. New South Wales, pt. ii, p. 71, pl. xiv, figs. 1, 2; pl. xv, fig. 4. Carboniferous: Farley and West Maitland, Northumberland County, New South Wales.

AFFINITIES.

The type species of this genus has been admirably figured and described by Mr. R. Etheridge, jun., after whom it is named. As *Etheridgia* and *Etheridgina* and probably other modifications of that surname are preoccupied, I follow the convenient *Salteraster* precedent.

Etheridge remarked that the starfish might have to be removed far from *Palæaster*, and even from the same order. From the absence of special marginal plates it appears to me advisable to include it in the Cryptozonia. It is allied to *Lepidaster* by the heavily-plated, blunt arms, large disc, and wide adambulacral plates.

Reference to the Lepidasteridæ renders it advisable to remark that the classification adopted in this paper is probably wrong in connection with this family or with the Tæniasteridæ. The former is included in the Cryptozonia, as it has no special marginal plates and the adambulacral plates are very wide (transversely to the arm) and resemble those of the Jurassic genus *Tropidaster*. It is possible that *Tropidaster* is a later representative of the Lepidasteridæ, in which the abactinal plates have broken up into an irregular set of granules.

But the Tæniasteridæ, in which the adambulacral plates act as marginals, and there is no special additional set of marginal ossicles, I have left in the Phanerozonia. It may, however, be urged that the Tæniasterids ought to go with the Lepidasterids. The reason why I have kept them apart is the idea that the adambulacral plates of Lepidasterids are true adambulacrals; whereas in the Tæniasterids these plates are rudimentary, and those described as adambulacrals are really marginal plates.

EXPLANATION OF PLATE XVI.

FIG. 1.—*Lindstromaster antiqua* (Hisinger), 1837.
,, 1*a*.—Outline of actinal surface of type-specimen, nat. size.
,, 1*b*.—The same magnified 4 diameters.
Bed C, corresponding to the Wenlock Shale, Gotland.

,, 2.—*Palæasterina Bonneyi*, sp. nov.
,, 2*a*.—Abactinal view of specimen, magnified 2 diameters.
,, 2*b*.—Actinal ,, ,, ,, 3 diameters.
Ludlow Shales: Leintwardine, Shropshire.

III.—A Discussion on the Use of the Terms Rock-weathering, Serpentinization, and Hydrometamorphism.

By George P. Merrill,
Head Curator, Dept. of Geology, U.S. National Museum, Washington, D.C., U.S.A.

IN the abstract of a paper by Mr. Thomas H. Holland, read before the British Association, Section C (Geology), Bristol, 1898, printed in the January number of this Magazine,[1] on "The Comparative Actions of Subaërial and Submarine Agents in Rock Decomposition," the author brings up again a question which the present writer has often had occasion to face, and has vainly tried to solve in a manner entirely satisfactory even to himself.

The question relates primarily to the limitation of the term weathering as applied to rocks, and indirectly to the general subject of hydrometamorphism and metasomatosis as manifested in the production of serpentine.

In my work on "Rocks, Rock-weathering, and Soils" (p. 174), is made the following statement:—

"The term weathering, as here used, is applied only to those superficial changes in a rock-mass brought about through atmospheric agencies, and resulting in a more or less complete destruction of the rock as a geological body, as where granitic rocks are resolved into sand and kaolinic material, with liberation of carbonates of the alkalies and of lime, and oxides of iron. It does not include those deeper-seated changes taking place below the zone of oxidation and which result mainly in hydration and the production, it may be, of new mineral species, as chlorite, sericite, zeolites, etc., but during which the rock-mass as a whole retains its individuality and geological identity. The distinction is not one that has been sharply insisted upon, and, indeed, geologists and petrologists as a rule have been extremely careless in their use of such terms as *alteration*, *decomposition*, and *weathering*. The distinction drawn here is essentially that made by Roth (Allgemeine u. Chemische Geologie) between *Verwitterung* and *Complicirte Verwitterung*. For reasons above stated and others given on p. 161, it seems best to limit the terms weathering and decomposition to processes involving the destruction of the rock-mass as a geological body, and to designate the purely mineralogical, deeper-seated changes, as alteration, which may or may not be due wholly to hydrometamorphism."

[1] Geol. Mag., January, 1899, pp. 30–1.

This is essentially the ground taken by Lindgren also,[1] and while it may be open to criticism, nothing better, so far as the writer is aware, has been suggested.

Let us take for purposes of discussion the serpentinization of the mineral olivine, as mentioned in the abstract of Mr. Holland's paper. The author states (p. 31) :—"In all these cases, however, although the action of the atmosphere is so striking, the results are purely superficial, and a specimen of rock taken from within a few inches of the clay products seldom shows a trace of hydrous decomposition, even in thin sections under the microscope. This is just as true for such delicate minerals as olivine and nepheline as for the commoner silicates. In many of the basic dykes, certainly pre-Cretaceous and probably Lower Palæozoic in age, the absence of serpentine is so complete that unusual precautions are often necessary for the determination of the olivine, whilst in the numerous occurrences of dunite throughout the Madras Presidency serpentine is extremely scarce."

Mr. Holland would account for this wide difference in the conduct of the olivine in Indian and European localities on the supposition that the European areas had, during the later geological periods, been submerged below the sea, while in southern India there are no evidences of any such depression since Lower Palæozoic time.

Just what would be the effect of prolonged submergence in sea-water on a mass of olivine rock the writer is not prepared to say, but he does express the doubt if simple weathering of the mineral is ever productive of serpentine. Has there been ever advanced any proof that serpentinization is a superficial phenomenon? If due to weathering we ought somewhere to meet with masses which are superficially converted into serpentine and gradually resume their normal character at greater depths.

So far as is to be judged from available literature the olivine granules in any mass of rock, however dense, show no greater degree of hydration (serpentinization) near the surface or along contacts where surface waters would most readily permeate, than in the interior of the mass. Further than this, serpentinization is as common, so far as the United States is concerned, in the arid portions of the West as in the humid East. In fact, this phenomenon is apparently entirely independent of climatic conditions. Is not the inference, then, fair that the process has gone on entirely independent of surface waters?

Although convinced that excepting in the purely physical weathering of arid regions hydration is a most important factor,[2] the absence of any but a very narrow zone of hydration products between the residual clay and fresh rock is not at all strange. Much depends on the texture of the rock and its mineral composition. In cases where the weathering is largely in the nature of solution and oxidization such abrupt changes are to be expected. The Fourche Mt. syenite, of Arkansas, an almost purely feldspathic

[1] 17th Ann. Rep. U.S.G.S., 1895–6, pt. ii, pp. 90–6.

[2] "Rocks and Rock-weathering," pp. 188, 234, etc.

rock, passes within the space of 2 cm. from a fine red-brown unctious clay to a massive fresh unchanged feldspar: the nepheline of the nepheline syenite of Mias in the Urals is eaten out below the surface of the more refractory feldspar, mica, zircons, etc., but gives in the closed tube only traces of water and shows under the microscope only incipient stages of hydration.

My own view of the case is, that the two phenomena are due to widely different causes; that serpentinization is a deep-seated process due to waters or vapours coming from considerable depths, and it may be even constituents of the magmas at the time of their intrusion. The almost complete absence of oxidization products in fresh serpentine is indicative of this. Again, serpentinization is a process involving a greater degree of hydration than is weathering. The serpentinized olivine rock of the Nijni Tagilsk platinum district yields 14·21 per cent. of water, while the brown crust which results from its weathering yields but 11·74 per cent. The serpentine of Harford County, Maryland, further, shows a loss on ignition of 18·15 per cent.,[1] while the hard red-brown crust produced on the immediate surface, through weathering, loses but 11·82 per cent. and the residual soil but 7·89 per cent. In the same manner soils derived by weathering from other highly hydrated magnesian rocks, as the so-called soapstone (altered pyroxenites), show a very considerable loss of water, even though the actual loss on ignition in the resultant soil may be a trifle greater than in the fresh rock.

These facts are mentioned in detail here since they do not seem to have been before noted, or at least their significance not realized. If serpentinization were a product of weathering, a shorter exposure to atmospheric influences, as in India, ought to result in merely a thinner coating of serpentine over the altered material. Were it a result of subaerial agencies, certainly the superficial alteration of olivine into serpentine ought to be more nearly universal. Yet, in several instances, as notably in the corundum areas of western North Carolina, the olivine is almost perfectly fresh, but on the immediate surface rotted away to a ferruginous clay.

That this process of hydration, hydrometamorphism, or alteration, whichever term may be used, is quite distinct from true weathering, is further shown by the corundum crystals of this same region. These are often superficially or quite altered to damourite. Yet both the corundum and the alteration products are so resistant to weathering, that they remain among the residues in the clays resulting from the decomposition (weathering) of the mother rock, whatever that may have been. Serpentine pseudomorphs after pyroxene are sometimes more refractory than the rock in which they are formed, and may be found with well-preserved crystal outlines in the débris resulting from its breaking down.[2] When rocks like

[1] In part due to C O, though the amount of this constituent cannot be over 3 or 4 per cent.

[2] J. Smith, "Crystals from Decomposed Trap": Geol. Mag., Dec. IV, Vol. VI (1899), p. 93.

the Nijni Tagilsk peridotites, which are largely serpentinized but still contain residuary olivines, undergo actual weathering, the olivines do not yield serpentine, but break up, as does the serpentine itself into free iron oxides, free silica, carbonates of magnesia, and unrecognizable earthy products.

The ideas put forward in this paper are not altogether new, and are in part in harmony and in part in conflict with those advanced by others.

Thus Bischoff says:[1] "The decomposition of a rock takes place only when it is exposed to the undisturbed action of atmospheric agents; while alteration, on the contrary, takes place when the rock is more or less beyond the reach of this action." On the other hand, Roth,[2] to whom we owe so much, speaks of both serpentine and zeolites as products of weathering (*Verwitterung*), but in his latest work[3] he so far changes his views or mode of expressing them as to call the deep-seated process *Complicirte Verwitterung*, in distinction from the purely superficial *Verwitterung*, due to atmospheric action. Moreover, in the paper "Ueber den Serpentin," to which reference is made above, he describes the processes and results incidental to the *Verwitterung* of the serpentine quite independently of those incidental to its first production.

Teall[4] apparently accepts unhesitatingly ideas contrary to those expressed by myself, for he says: "The alteration of olivine by surface agencies—water, carbonic acid, and oxygen—gives rise to serpentinous and other pseudomorphs."

Consideration along these lines led the present writer in the work to which reference has been made to attempt making a distinction between true weathering and the more deep-seated process which he called hydrometamorphism. Surely processes so widely different as those resulting in the production of a serpentine from a peridotite and the final destruction through oxidation, carbonization, and partial dehydration of this same serpentine, should not be confounded under the same name. The distinction, it is true, is not one that can at all times be readily made. As the petrologist finds difficulty in separating his plutonic from the effusive rocks, so here are no hard and fast lines, and it is often impossible to state at just what point one shall assume that superficial processes cease and the deep-seated begin. The writer's conclusions are to the effect that the zone of oxidation forms the natural and easiest recognizable limit. The processes within this zone are those of weathering; those below, whether brought about by superficial waters deprived of their free oxygen and carbonic acid, or by deep-seated waters welling upwards, are those of hydrometamorphism, metasomatosis, alteration, or whatever suitable name may be adopted.

[1] "Chemical and Physical Geology," Paul & Drummond's English translation, 1854, vol. iii, p. 86.

[2] "Über den Serpentin, etc.": Abhandl. der K. Akademie der Wiss. zu Berlin, ii (1869), p. 42.

[3] "Allegemeine u. Chemische Geologie," 1893.

[4] "British Petrography," p. 85.

In conclusion, one might urge the necessity of closer observations regarding the formation of serpentine from olivine or other anhydrous magnesian silicates. That it is through a process of hydration is self-evident, but as to the conditions under which it goes on literature is strangely silent. Is the process still going on in the exposed masses now open to our inspection, or is it at a standstill? The writer is of the present opinion that both this process and that resulting in the formation of zeolites and chlorites have ceased, so far as material available for study is concerned. They are due to conditions which do not exist on the immediate surface, except it may be in such sporadic and unusual occurrences as those of Plombieres, or those more recently described by F. Gounard[1] and by Lacroix.[2] This paper is, however, written more for the purpose of eliciting the opinions of others than of expressing those of the writer.

IV.—Woodwardian Museum Notes: A New Trilobite from Mount Stephen, Field, B.C.

By F. R. Cowper Reed, M.A., F.G.S.

A REPRESENTATIVE collection of fossils from the Middle Cambrian beds of Mount Stephen, Field, British Columbia, has recently been brought back by Mr. S. H. Reynolds, M.A., F.G.S., and presented to the Woodwardian Museum. The fauna has been described by Rominger[3] and Walcott[4]; and the latter[5] has compared it to that from the Highland range, near Pioche, Nevada, and from near Antelope Spring, Western Utah. The section at Field has been described by Mr. R. G. McConnell.[6]

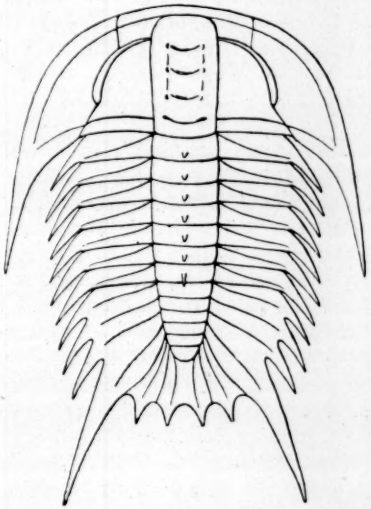
The collection made by Mr. Reynolds contains the following species:—

Ogygopsis Klotzi (Rominger).
Ogygopsis, sp.
Bathyuriscus Howelli (Walcott).
Olenoides nevadensis (Meek).[7]
Olenoides cf. *quadriceps* (Hall & Whitfield).
Ptychoparia Cordilleræ (Rominger).
Ptychoparia, sp.

[1] Bull. de la Société Minéralogique de France, vol. v (1882), p. 268.
[2] Comptes Rendus Paris Acad. Sci., vol. xxiii (1896), p. 761.
[3] C. Rominger, "Description of Primordial Fossils from Mount Stephens, North-West Territory of Canada": Proc. Acad. Nat. Sci. Philadelphia (1887), p. 12, pl. i.
[4] C. D. Walcott, "Cambrian Fossils from Mount Stephens, North-West Territory of Canada": Amer. Journ. Sci., ser. III, vol. xxxvi (1888), p. 163. "Descriptions of New Genera and Species of Fossils from the Middle Cambrian": Proc. U.S. Nat. Mus., vol. ii (1889), p. 441.
[5] Correlation Papers, Cambrian: Bull. U.S. Geol. Surv., No. 81 (1891), pp. 170–1, 326–7, 360–1, 366, and pl. ii.
[6] Geol. Surv. Canada, new ser., vol. ii (1886–7), pp. 24D–30D.
[7] Matthew (Trans. Roy. Soc. Canada, ser. II, vol. iii (1897), sect. iv, No. 7, p. 186) contends that Dames' name *Dorypyge* (Dames in Richthofen's "China," iv: Beitr. z. Paläont., 1883, p. 23, t. i, figs. 1–6) has the priority of *Olenoides*. Matthew here describes a variety of *Olenoides* (*Dorypyge*) *quadriceps* from the St. John Group of Hastings Cove.

Agnostus interstrictus (White).
Oryctocephalus Reynoldsi, n.sp.
Acrotreta gemma (Billings).
Kutorgina pannula (White).
Lingulella ella (Hall & Whitfield) ?
Scenella cf. *varians* (Walcott).
Hyolithes, sp.

All the above trilobites have been recorded previously with the exception of *Olenoides* cf. *quadriceps* and *Oryctocephalus Reynoldsi*, n.sp., the latter of which I have much pleasure in naming in honour of its discoverer. The specimen is of peculiar interest as it consists of a complete individual in perfect preservation, whereas our previous knowledge of the genus has been restricted to the disconnected head-shields and pygidia of *Orycto. primus* described by Walcott.



Restored outline of *Oryctocephalus Reynoldsi*, sp. nov. Middle Cambrian: Mount Stephen, Field, British Columbia. Magnified about four times natural size.

Oryctocephalus Reynoldsi, n.sp.

Head-shield transversely semicircular, broad, short, more than twice as broad as long. Glabella elongate, cylindrical, sides parallel [1]; reaches margin; front rounded; surface marked by four pairs of transverse furrows. The three anterior pairs of transverse furrows are equidistant, and terminate in small deep pits within the margin of the glabella; each furrow is shallow and arches slightly backwards in the centre. A shallow groove parallel to the axal furrow connects the pits on each side longitudinally. The fourth transverse furrow crosses the base of the glabella at a distance from the third furrow rather greater than the latter from the second or the second

[1] Owing to slight crushing the glabella in our specimen appears to be slightly wider in front than at the base.

from the first, and is stronger and deeper than the others, but similarly does not reach the axal furrows, terminating on each side in an elongated pit within them, and thus marking off incompletely the strong rounded occipital ring. Axal furrows straight and strongly defined.

Fixed cheeks nearly as broad as glabella behind ocular ridge, but narrower in front of it. No frontal limb present, as glabella reaches margin. Margin narrow, raised, and rounded, with concentric striations on lower surface. Palpebral lobe arched outwards, narrow, long, with a groove separating it from fixed cheeks. Ocular ridge narrow, continuous with palpebral lobe and touching glabella just in front of anterior transverse furrow.

Free cheeks narrow, slightly longer than fixed cheeks and reaching further back, furnished with narrow raised margin, produced at genal angles into long straight spines obliquely directed outwards and backwards and nearly as long as the thorax.

Neck-furrow at base of cheeks strong, makes a sudden short backward bend where it crosses from the fixed on to the free cheek; neck-ring narrow.

Thorax composed of seven segments; narrower than the head-shield, being only the width of the 'middle-shield.' Axis cylindrical, expanding slightly in width towards the middle, then gradually tapering to the pygidium; narrower than pleuræ on each side. Axal furrows deep. Axial rings rather wide, each possessing median, slender, short spine (crushed down on body-ring or broken off); the spine on the last one is longer than the others.

Pleuræ wider than axis, flattened and horizontally extended and in close contact for three-fourths of their length, beyond which point they become free, are slightly bent downwards and backwards, contracting rapidly into slender, rounded, sharp spines. Each pleura is marked with a strong diagonal furrow curving backwards from the inner anterior angle on the axal furrow to the base of the spine.

Pygidium large, nearly as long as thorax, wider than long, with straight anterior edge; composed of six segments. Axis long, narrow, conical, obtusely pointed, consisting of five complete rings and a small terminal segment, marked off by regular transverse furrows. The axis does not reach the posterior margin, being only about two-thirds the length of the pygidium. Lateral lobes composed of six fused pleuræ. The first three are of equal size and preserve nearly the same width for their whole length, but end in finely pointed slender spines projecting freely beyond the margin and directed obliquely backwards, similar to those of the thoracic pleuræ. Each pleura is also marked by a strong diagonal furrow, but the interpleural furrows are almost obsolete, so that the pleuræ appear fused together. The fourth pair of pleuræ are of the same width at their base as the preceding ones, but expand towards the pygidial margin, beyond which they taper into long free stout spines directed backwards and slightly outwards, parallel to the spines of the first three pleuræ but at least three times their length, giving a distinctive and striking appearance to the pygidium. A strong

diagonal furrow crosses each of these fourth pleuræ, but is not continued on to the free spine. The separation of this pair of pleuræ from the fifth pair is well marked by distinct interpleural furrows.

The fifth pair of pleuræ, which are short and wider towards their extremity than at their base, are directed backwards and slightly outwards, ended in short rounded spines projecting freely beyond the margin. The sixth pair of pleuræ are fused together in the middle line directly behind the axis, but are separated by a well-marked furrow from the preceding pair, which they resemble in shape. They are directed straight backwards, and end in short rounded spines of the same size as those of the fifth pair and likewise projecting freely beyond the margin. The strong diagonal furrows of this sixth pair of pleuræ are parallel to each other, and run down the centre of each pleura to the base of the spine.

MEASUREMENTS.

	mm.
Length of specimen	17·5
,, head-shield	6·0
,, thorax	6·5
,, pygidium	5·0
Width of head-shield	14·5
,, thorax (front end)	9·5
,, pygidium	8·5

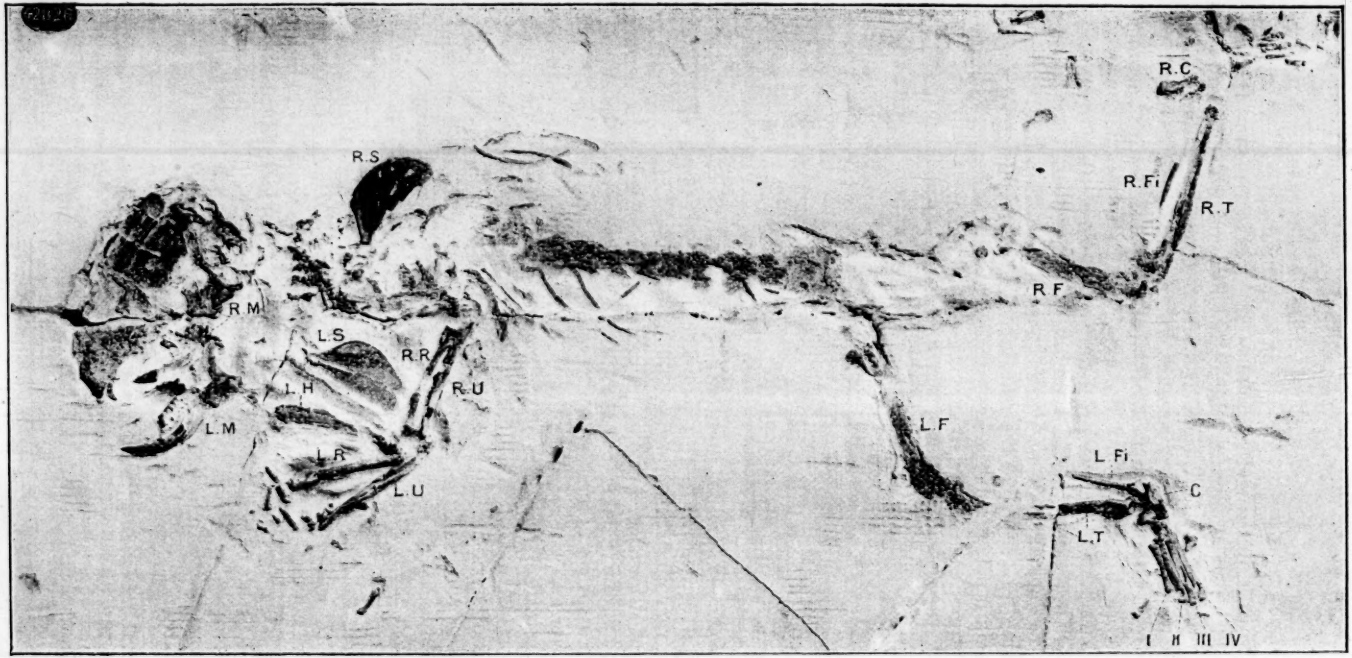
Affinities.—There has been only one species (*O. primus*, Walcott) [1] described belonging to this genus, and to this form *O. Reynoldsi* bears a very close resemblance. The head-shield offers scarcely any points of difference, but the palpebral lobes of our new form are longer, and the genal spines are also more elongated. The thorax of Walcott's species is unknown. The pygidium of our form differs by its shorter axis not reaching the posterior margin, by the possession of six instead of five pairs of pleuræ, by their diagonal furrows and by the relative development of their free pointed extremities. The number of segments in the axis is, however, the same, and the freely projecting points of the pleuræ with the reduced length of the last pair behind the axis give a general appearance of similarity.

Though the head-shield shows such distinct and unique features, particularly in the lobation of the glabella, the resemblance of the pygidium to that of several species of *Olenoides* (*O. quadriceps*, Meek, *O. wahsatchensis*, Hall & Whitfield, *O. Fordi*, Walcott) deserves notice. The pleuræ recall those of *Paradoxides*, while the spinose rings of the axis remind one of *Olenoides* (*Zacanthoides*) *typicalis* (Walcott) and *O. nevadensis* (Meek).

Oryctocephalus primus (Walcott) is found in the Middle Cambrian Limestone, east of Pioche, Nevada,[2] but so far as I know the genus has not been recorded elsewhere.

[1] Bull. U.S. Geol. Surv., No. 30 (1886). "Cambrian Faunas of North America," pt. 2, p. 210, pl. xxix, figs. 3, 3*a*: Tenth Ann. Rep. U.S. Geol. Surv., 1888. "The Fauna of the Olenellus Zone," p. 653, pl. xcv, figs. 4, 4*a*.

[2] Walcott: Bull. U.S. Geol. Surv., No. 30 (1886), p. 210.



Skeleton of *Sciurus Bredai*, H. v. Meyer, 1848.

Middle Miocene : Oeningen, Southern Germany. (Two-thirds natural size.)

V.—Some Rodents from the Middle Miocene Lacustrine Deposits of Oeningen, Southern Germany.

By Dr. C. I. Forsyth Major, F.Z.S.

(PLATE XVII.)

In the Geological Department of the British Museum (Natural History) are preserved a certain number of slabs from Oeningen, exhibiting skeletons of Rodents. Partly owing to unskilful developing, partly to the absence of the counterpart-slab, several of them are in such a crushed and otherwise imperfect condition, that in some cases not even the genus could be made out with certainty; which is equivalent to saying that their interest is little beyond that of mere curiosities. On closer examination it appeared to me that in some instances the case was not quite so hopeless, and that by carefully developing the more important parts still concealed by the matrix, a more satisfactory state of things might be obtained. The following pages are an account of the result arrived at.

The splendid series of Oeningen Fossils in the British Museum (Natural History) formed part, with a few exceptions, of Professor van Breda's collection in Haarlem, which was purchased of the Executors of Dr. de Haan, his son-in-law, in 1871 by the Trustees of the British Museum. Dr. Henry Woodward informs me that most, if not all, of these specimens were collected in the quarries of Oeningen by Oswald Heer, when a young man struggling to pay his own college fees at the University, and by him transmitted for purchase to Professor van Breda. (See Obituary of Prof. O. Heer, Geol. Mag., 1883, Dec. II, Vol. X, p. 576.)

1. Sciurus Bredai, H. v. Meyer.

Sciurus Bredai, H. v. Meyer: Neues Jahrbuch, p. 472 (1848); Schlosser, Die Nager des europäischen Tertiärs, Palaeontographica, xxxi, p. 88 (1884).

Sciurus spermophilinus, Depéret: Arch. Mus. Lyon, iv, p. 152, pl. xiii, figs. 14, 14*a* (1887); v, p. 48, pl. i, figs. 26, 27 (1892); Forsyth Major, Proc. Zool. Soc. London, p. 193, pl. x, figs. 4–9 (1893).

The only reference made by H. v. Meyer to this name is to the effect that it refers to a new species of *Sciurus*, from Oeningen, and preserved in the van Breda Collection at Haarlem.[1]

Amongst the MSS. of H. v. Meyer, deposited in the Munich Palæontological Museum, Schlosser came upon a rough ('flüchtige') sketch of the specimen, representing the mandible, scapula, humerus, and hind-limbs; he was thus enabled to give the following measurements (in millimetres): scapula, 16?; humerus, 26·5; femur, 34; tibia, 36; metat. iii, 12; diastema between incisors and premolar, 6; length of cheek-teeth, 7 (p.—m. 2, 5·4). Schlosser adds that the limbs are remarkably short as compared with the length of the teeth-row,

[1] "... das erste Stück, welches ich in der reichen Sammlung des Professors van Breda erblickte, war ein neuer Nager von Oeningen, dem ich den Namen *Sciurus Bredai* beigelegt habe." (Neues Jahrb., p. 472, 1848.)

and that the species may be identical with one of the *Sciurus* species from Sansan.[1]

Several years afterwards, '*Sciurus Bredai*' is by the same author, without justification, given as a synonym of *Sciurus Gervaisianus*, Lart., from Sansan, and of *Sciurus spermophilinus*, Dep., from La Grive-Saint-Alban (Isère).[2]

To this identification Depéret rightly observes[3] that there is no sufficient reason for the assumption of specific identity between *Sc. Bredai* and *Sc. spermophilinus*; in fact, dimensions *alone* are a very unsafe criterion to rely upon for specific distinction or identification. The same must be said of *Sc. Gervaisianus*, Lart., from Sansan, which might come into consideration as a synonym of *Sc. Bredai*, since both Lartet and Gervais state it to be smaller than *Sc. vulgaris*, wherein it agrees with the Oeningen squirrel. But no other characters are given of the Sansan fossil, and Filhol, in his monograph of Sansan,[4] says that he is unacquainted with the specimens mentioned by his predecessors.

In the "Catalogue of the Fossil Mammalia in the British Museum (Natural History),"[5] Lydekker refers to the specimen No. 42,826, from Oeningen, in the following words:—

"*Sciurus*, sp. (cf. *S. bredai*, H. v. Meyer).

42,826. The much crushed skeleton of a rodent, probably belonging to the present genus, from the Upper Miocene of Oeningen, Switzerland. It is not improbable that this specimen, which indicates an animal rather smaller than *S. vulgaris*, may belong to Meyer's ill-defined *S. bredai*, which Schlosser suggests may be identical with one of the Sansan species. Van Breda Collection. Purchased 1871."

Both Schlosser, in 1884, and Depéret, in 1892, state that the type of *Sciurus Bredai* is at Haarlem; there can be no doubt, therefore, that it is the No. 42,826, which has been incognito in the British Museum (Natural History) since 1871, when the van Breda Collection was purchased "from the executors of Dr. de Haan, of Haarlem."[6] My reasons for this assumption are very obvious, for:

(1) No. 42,826 is the only specimen of *Sciurus* from Oeningen in the van Breda Collection.

(2) The bones mentioned and measured by Schlosser, after H. v. Meyer's sketch of the type, are present in the British Museum specimen, and in such a condition that the measurements published by Schlosser could be taken from them. The slight divergences between the latter author's measurements and my own are sufficiently explained by the fact that the former were not taken from the original but from a rough sketch, and that my accurate measurements

[1] Palaeontographica, xxxi, p. 88 (1884).
[2] Beitr. Pal. Oestr.-Ung., viii, pp. 470, 471 (1890).
[3] Arch. Mus. Lyon, v, p. 50 (1892).
[4] H. Filhol, "Études sur les Mammifères fossiles de Sansan": Ann. Sci. Géol., xxi, 20, No. 1, pp. 38, 39 (1891).
[5] Part i, p. 211 (1885).
[6] Cat. Foss. Mamm., i, p. xii.

could only be taken after some of the bones had been fully developed. They are as follows :—

	mm.
Scapula	20·5
Humerus	26
Ulna	28
Femur	32·5
Tibia	37
Metat. iii	13
Calcaneus	13·5
Lower p.—m. 2	6

I must postpone the description of the limb-bones for a future opportunity, when limb-bones of recent species, it is hoped, may be available for comparison. The characters of the teeth come in the first line for a comparison with other Miocene squirrels. When the lower incisor of the Oeningen fossil was laid bare, it revealed a longitudinal striation of the enamel; this peculiarity, by itself, at once settles the question as to the affinities of the Oeningen squirrel. In the *Sc. spermophilinus*, Dep , from La Grive, I have described and figured the same character of the lower incisors;[1] so that the identity of the La Grive species with *Sc. Bredai* is fairly established.

The lower molars in the Oeningen specimen are unfortunately much worn and m. 3 is missing, so that I am unable to verify two other characters which I have described in *Sc. spermophilinus* and by which it agrees with some Oriental squirrels, viz., the great elevation of the antero-internal cusp and the elongation of m. 3.

2. Lagopsis verus (Hensel).

Lagomys Oeningensis, H. v. Meyer: Neues Jahrbuch, p. 58 (1836); p.p.; id., Fossile Säugethiere, etc., von Oeningen, p. 6, pl. iii, fig. 1 (1845); Biedermann, Petref. aus d. Umgegend von Winterthur, II, Die Braunkohlen von Elgg, p. 13, pl. iii, figs. 1–3 (1863); Lydekker, Cat. Foss. Mamm. Brit. Mus., i, p. 256 (1885), specim. No. 42,815 (42,816 ?, 42,820 ?).

Lagomys verus, Hensel: Zeitschr. deutsch. geol. Ges., viii, p. 688, pl. xvi, figs. 12, 13 (1856); Depéret, Arch. Mus. Lyon, iv, p. 164, pl. xiii, figs. 16, 17 (1887).

Titanomys visenoviensis, H. v. Meyer: Palaeontogr., xvii, p. 228 (1870); p.p.

Lagomys (*Lagopsis*) *Oeningensis*, Schlosser: Palaeontogr., xxxi, p. 13 (1884); p.p.

Lagomys (*Lagopsis*) *verus*, Schlosser: op. cit., p. 13, pl. xii, figs. 40, 46, 49 (1884); Depéret, Arch. Mus. Lyon, v, p. 57 (1892); p.p.

Laurillard was the first to recognize that lagomorphous Rodentia occur at Oeningen,[2] whereas a specimen in the British Museum,

[1] P.Z.S., p. 191, pl. x, fig. 5 (1893).

[2] R. I. Murchison, "On a Fossil Fox found at Oeningen, near Constance, etc.": Trans. Geol. Soc. London, iii, 2, p. 285 (1832). "Another animal of this order [i.e. Rodentia] was brought from the quarries this year by Professor Sedgwick, which M. Laurillard, of the Jardin du Roi, Paris, refers to *Lagomys*."

previously figured by König, had been assigned by the latter to the genus *Anœma*, under the name of *Anœma Oeningensis*.[1]

In his first note on the *Lagomys*-like Rodents of Oeningen, Hermann von Meyer was not aware that more than one form is represented in the deposit; accordingly, he comprises all the specimens under the name *Lagomys Oeningensis*.[2] Later on, in his monograph of the fossil Vertebrates of Oeningen,[3] he arbitrarily sets aside König's specific name of the smaller form, for which he adopts a manuscript name by Von Tschudi, founded on one of the labels, and applies the name *Lagomys Oeningensis* to the larger-sized specimens.

In a memoir read before the Linnean Society, and which will be published about the same time with the present note, I have at length dealt with the smaller form, whose proper name will be *Prolagus Oeningensis* (Kön.), but with which we have not to deal here. However, the Oeningen specimens of Rodents under examination having, from their unsatisfactory condition, occasioned much of the prevailing confusion, it is necessary before making an examination of the fossil in the British Museum, which I have determined as *Lagopsis verus*, to glean whatever additional information we are able from other fossils of the same and contemporaneous deposits.

Two skeletons from Oeningen are ascribed to '*Lagomys Oeningensis*' in the "Fauna der Vorwelt"—one from the Carlsruhe Museum, on pl. ii, fig. 1; the other from the Seyfried Collection at Constance, on pl. iii, fig. 1. Both agreeing approximately in size, H. v. Meyer assumes as a matter of course that they belong to the same species. The former specimen affords no evidence as to the important characters of the number and form of the cheek-teeth. In the latter the number of the lower cheek-teeth is given as four, the writer adding that neither is the posterior tooth tripartite as in recent species of *Lagomys*, nor does the shape of its alveolus favour such an assumption. H. v. Meyer was under the erroneous belief that the recent *Lagomys* had only four lower cheek-teeth, the posterior one complicated by the addition of a third lobe. As a matter of fact all the members of the recent genus *Lagomys* have five lower cheek-teeth, the fourth being bipartite like the two preceding it in the series, whilst the fifth is a small simple cylinder.

The insufficient acquaintance with the dentition of *Lagomys* prevented H. v. Meyer from investigating if perchance in the Seyfried specimen there was an alveolus for a fifth cheek-tooth. This omission and the error by which it was engendered have both proved fatal.

H. v. Meyer's error as to the number of teeth in *Lagomys* was set right by Hensel[4]; the former author was thereby induced to transfer

[1] König: Icones Foss. Sect., pl. x, fig. 126 (1825).
[2] Neues Jahrbuch, p. 58 (1836).
[3] H. v. Meyer: "Zur Fauna des Vorwelt, Fossile Säugethiere, Vögel und Reptilien aus dem Molasse-Mergel von Oeningen," p. 7 (1845).
[4] Zeitschr. deutsch. geol. Ges., viii, p. 698 (1856).

his '*Lagomys Oeningensis*' to the genus *Titanomys*,[1] assuming, erroneously again, this latter genus alone to be characterized by four lower cheek-teeth only, the posterior of which is bipartite.

Meanwhile a real step forward had been made by Hensel, in describing his '*Lagomys verus*,'[2] which was founded on a fossil communicated to him by Quenstedt; its provenance is not "aus den Bohnerzen der schwäbischen Alp," but from the Molasse of Althausen, Württemberg.[3] The species is based on the fragment of a mandibular ramus, and exhibits, in opposition to '*Myolagus*' (= *Prolagus*), described in the same article, five lower cheek-teeth, the posterior one being a small cylindriform tooth, as in the recent *Lagomys*; the anterior one is, also as in the latter, composed of only one cylinder, but of a more complicated pattern than in *Lagomys*.

Hensel's *Lagomys verus* having the size of H. v. Meyer's *L. Oeningensis*, and both localities being of the same geological age, the suspicion naturally arises that the two names might be synonyms. Hensel does not discuss this side of the question, and he could not do so; for, as he rightly says, the specimens of *L. Oeningensis* of the "Fauna der Vorwelt" are insufficiently characterized.

In his "Nager des europäischen Tertiärs,"[4] Schlosser enumerates '*Lagomys* (*Lagopsis*) *Oeningensis*, H. v. Mey.,' as distinct from '*Lagomys* (*Lagopsis*) *verus*, Hens.,' and the same course is followed by Zittel.[5] However, the former writer, when describing in the same memoir[6] specimens from other localities, suggests that after all '*Lagomys Oeningensis*,' from Oeningen, may be identical with *L. verus*, Hens. Three more or less complete mandibular rami from Deggenhausen, Elgg, and Hohenhöven respectively, had been mentioned by H. v. Meyer, and drawings of their teeth, found amongst his MSS., have been reproduced by Schlosser.[7] They show an agreement in their p. 2 with Hensel's *Lagomys verus*, and Schlosser therefore concludes[8] that they are the same species. He also proposes[9] to raise Hensel's *Lagomys verus* to generic rank—*Lagopsis*—chiefly on account of the difference from the recent *Lagomys* in the lower anterior premolar (p. 2).

Like the Oeningen '*Lagomys Oeningensis*,' no last molar (m. 3) is to be seen in the specimens from the three localities mentioned. Schlosser does not attach any great weight to the absence of this small tooth in the three specimens figured from H. v. Meyer's MSS. Neither do I: but for different reasons from those given by the former writer in the following passage, and with which

[1] Palaeontographica, xvii, p. 228 (1870).
[2] Loc. cit., p. 688.
[3] Quenstedt: Handbuch d. Petrefaktenkunde, 2te Aufl., p. 45, fig. 6te (1867); id. H., 3te Aufl., p. 55, fig. 7 (1885).
[4] Palaeontographica, xxxi, p. 31 (1884).
[5] Handbuch d. Palaeontologie, iv, p. 553 (1891–93).
[6] Loc. cit., p. 32.
[7] Loc. cit., p. 31, pl. viii, figs. 40, 46, 49.
[8] Loc. cit., pp. 31, 32.
[9] Loc. cit., pp. 28–31.

I completely disagree: "Auf das Fehlen des letzten einfachen Backzahnes bei den drei von H. v. Meyer gezeichneten Exemplaren darf wohl nicht allzuviel Gewicht gelegt werden. Es ist nicht unmöglich, dass auch hier, wie bei *Titanomys visenoviensis*, im normalen Kiefer nur drei zweilobige Molaren vorhanden sind und dass daher der stiftförmige m. 4 [meaning m. 3] des Hensel'schen Originales als Analogon des bei *T. visenoviensis* abnorm vorkommenden Lobus des m. 3 [meaning m. 2] betrachtet werden muss."[1] This whole statement is somewhat vague and obscure; the writer seems to assume (1) that in *T. visenoviensis* both the m. 3 and a third posterior lobe of m. 2 occur only abnormally; and (2) that in '*Lagomys verus*' the presence of a m. 3 is likewise an abnormal occurrence. From these two assumptions the inference is drawn that in the type of *Lagomys verus* m. 3 is the 'analogue' of the equally 'abnormal' third lobe in m. 2 of *Titanomys visenoviensis*. The writer concludes by saying that he is almost inclined to consider the presence of m. 3 as a juvenile character, and that this tooth is caducous ('hinfällig'). This is very probably true with regard to *Titanomys visenoviensis*, and I have myself suggested it in the memoir in course of publication. The last lower molar of '*Lagomys verus*' is caducous after a manner, viz., it has often dropped out in the fossil, its alveolus being filled with matrix. But, as I shall show hereafter, it is decidedly erroneous to consider this tooth as caducous in the sense attached by Schlosser to this term; and so are all the other suggestions tentatively put forward in the passage quoted above.

Schlosser seems not to have had access to a publication by Biedermann in which '*Lagomys Oeningensis*, H. v. Mey.,' from the lignites of Elgg, near Winterthur (Switzerland), is described and figured.[2] The description is somewhat insufficient, and so are the figures, the details of the triturating surface of the molars not being described or represented. Still, enough is given to allow of a definite conclusion. A fifth lower molar is said to be present, smaller than in *Lepus*, and not, as in the latter, composed of two columns or prisms. The two upper figures of mandibular rami in figs. 2 and 3, pl. iii, which represent clearly the outer side, show in the anterior cheek-tooth (p. 2) two lateral grooves, which are characteristic of this tooth of *Lagopsis verus*. This character, as well as the evident rootless condition of the cheek-teeth, enables us to exclude at least the figured specimen of *Titanomys Fontannesi* (Dep.), which might otherwise need consideration, being of about the same size as *Lagopsis verus* and also on account of its occurring elsewhere associated with the latter. In one of his two splendid memoirs on the Miocene Vertebrates of the Rhône Basin, Depéret has described and figured, from the Middle Miocene of La Grive-Saint-Alban, a mandibular ramus exhibiting the characteristic anterior premolar of Hensel's *Lagomys verus*, and provided besides

[1] Loc. cit., p. 32.

[2] W. G. A. Biedermann: Petrefacten aus der Umgegend von Winterthur, 2tes Heft, Die Braunkohlen von Elgg, p. 13, pl. iii, figs. 1, 2, 3 (1863).

with the fifth simple molar.[1] I have myself collected at La Grive about half a dozen mandibular rami of the same Rodent, in all of which either this fifth tooth itself or its very distinct alveolus is present.

The foregoing observations mark another step in advance, for they show conclusively that the fifth lower molar of *Lagopsis verus* does not occur 'abnormally,' but that it is a characteristic feature of the species, as it is also in the recent *Lagomys*.

The upper cheek-teeth of *Lagopsis verus* are unknown up to the present. Depéret has published from La Grive a left palate devoid of teeth, but exhibiting very distinctly the alveoli of the five cheek-teeth; he assigns this fossil, quite rightly in my opinion, to *Lagopsis verus*.[2] At the same time he figures and describes the left palate of '*Lagodus Fontannesi*,'[3] in which two cheek-teeth are preserved; in the memoir alluded to above, I have arranged the latter under the genus *Titanomys—T. Fontannesi* (Dep.). No mandibles of this '*Lagodus Fontannesi*' are mentioned in Depéret's first memoir quoted, nor in the later one.[4] This circumstance seems to be the reason which has induced Schlosser to suggest that *Lagopsis verus* and '*Lagodus Fontannesi*' are the same species;[5] and, unfortunately, Depéret, in his second memoir,[6] inclines towards the same opinion, and has consequently omitted *Lagodus Fontannesi* from his latest list of the Vertebrates of La Grive,[7] *Lagomys verus* alone being mentioned. It may be asked, what then becomes of the left palate represented in the above-mentioned fig. 17 of Depéret's first memoir, which both writers overlook entirely when they unite together the two so widely different forms of *Lagopsis verus* and *Titanomys Fontannesi*. It is somewhat surprising that, according to Depéret,[8] more than fifty mandibular rami of *Lag. verus* have been found at La Grive, whilst not a single one of *Tit. Fontannesi* is mentioned; and I therefore venture to suggest that the mandibles of *Titanomys Fontannesi*, which are approximately of the same size as those of the other form, have not been recognized amongst the numerous rami collected. I have myself collected at La Grive over twenty mandibular rami, half-a-dozen of which belong to *Lagopsis verus* and seventeen to *Tit. Fontannesi*. Both are figured and described elsewhere, and I will therefore only briefly mention here that, apart from the difference in the cheek-teeth, the anterior premolar being the most important in this respect, the two genera present some difference in the shape of the bone as well. The horizontal ramus of *Tit. Fontannesi* is lower and more elongate;

[1] Arch. Mus. Lyon, iv, p. 164, pl. xiii, figs. 16, 16*a* (1887).
[2] Loc. cit., p. 164, pl. xiii, fig. 17.
[3] Loc. cit., p. 171, pl. xiii, fig. 19.
[4] "La Faune des Mammif. mioc. de La-Grive-Saint-Alban": Arch. du Mus. d'Hist. Nat. de Lyon, v (1892).
[5] Beitr. Pal. Östr.-Ung., viii, pp. 86, 87 (1891).
[6] Loc. cit., p. 58.
[7] Depéret, "Sur la Classification et le Parallélisme du Système Miocène": Bull. Soc. Géol. France, xxi, p. 206 (1893).
[8] Arch. Mus. Lyon, iv, p. 164 (1887).

the diastema between the anterior premolars and the incisors is longer than in *Lagopsis*, and the inferior outline of the ramus, when viewed from the external side, is straighter in *Titanomys*.

Of upper cheek-teeth, which I feel entitled to ascribe to *Lagopsis verus*, I have found two amongst the fossils of La Grive (Brit. Mus. Geol. Dep., M. 5,264). The median of the three upper premolars of the recent *Lagomys*, p. 2, is characterized by a crescent enamel-folding, which opens freely on the outer margin of the tooth, near its anterior angle.[1] *Lagopsis* being the one Tertiary genus which in the form of its lower teeth comes nearest to *Lagomys*, it might be anticipated that the upper teeth of the fossil would likewise show a near approach to the recent *Lagomys*. In fact, one of the isolated teeth just mentioned, from La Grive, exhibits the same somewhat triangular outline, the apex being turned outwards, as the second upper premolar of *Lagomys*, and about the same characteristic enamel folding. It can therefore with certainty be determined as p. 2 of *Lagopsis*; I have described and figured it elsewhere. It can at once be distinguished from p. 2 of *Prolagus Oeningensis* (Kön.), occurring in the same deposits: in *P. Oeningensis* this tooth is much smaller, has a triangular outline with the apex turned *inwards*, and has a second enamel crescent, smaller than the one corresponding to the single one in the tooth of *Lagopsis*, and situated externally to it. The upper p. 2 of *Titanomys Fontannesi*, which approaches nearer in size to *Lagopsis*, though slightly smaller, is provided with roots, and, besides, presents other differences which are referred to in my memoir.

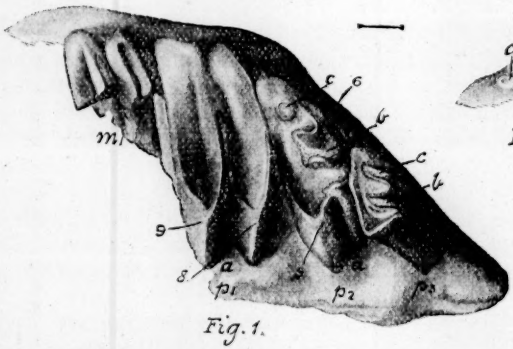


Fig. 1.—Triturating surfaces of the three upper premolars, right side, of *Lagopsis verus* (Hensel), much enlarged; from the specimen No. 42,815 in the British Museum, Geological Department.

Fig. 2.—The median premolar, p. 2, of same, from behind, much enlarged.

a, internal enamel folding; *b*, enamel crescent; *c*, enamel ring; 6, cusp, separating *b* and *c*; 8, antero-internal cusp; 9, postero-internal cusp.

We know, then, from La Grive, a deposit contemporaneous with Oeningen, apart from the small *Prolagus Oeningensis*, two larger lagomorphous Rodentia, both of approximately equal size. It is

[1] See R. Hensel in Zeitschr. deutsch. geol. Ges., viii, pl. xvi, figs. 1–3 (1856).

therefore *a priori* not unlikely that the larger forms from Oeningen, comprised generally under the single denomination '*Lagomys Oeningensis*,' may equally include two different animals. For this reason something more is required than mere measurements, if we wish to determine more satisfactorily these so-called '*Lagomys Oeningensis*.'

On inspection of the specimen No. 42,815 from Oeningen, several cheek-teeth were detected in a fragment of the cranium examined from their inner side, the bone being broken away; the lower parts of these teeth were near the crown; this latter, however, was hidden in the matrix when the specimen was placed in my hands. By carefully removing the matrix, the triturating surface of the three anterior cheek-teeth (the three premolars) could be developed, and, as a result, it became at once apparent that the fossil is a *Lagopsis*. The posterior of the three teeth (p. 1) exhibits the pattern which is shown by the homonymous premolar of *Lagomys* and by the latter's two true molars. On the outer side of this tooth is a shallow and open groove, which, as far as can be made out with a strong lens, has no enamel border. From the middle of the inner margin a lozenge-shaped narrow fold of enamel runs transversely across two-thirds of the breadth of the triturating surface, towards the outer side; the posterior enamel bordering of this fold is raised into a strong crest, running parallel with the anterior enamel bordering of the tooth, both presenting a slight anterior convexity. The enamel folding is filled with cementum in its outer narrower portion, its wider internal opening being devoid of this substance. The pattern of the median premolar, p. 2, proves that the isolated tooth from La Grive, before mentioned, has been rightly determined as p. 2. There is only a comparatively shallow internal enamel folding present in this tooth (*a*, Fig. 1); the greater part of the triturating surface being occupied by the enamel crescent (*b*, Fig. 1) before described in the tooth from La Grive. Outside from the crescent appears a small enamel ring (*c*, Fig. 1) filled with cementum, doubtless the vanishing homologue of the outer enamel crescent *c* of *Titanomys* and *Prolagus*, as elsewhere described and figured. In the La Grive specimen there is a mere vestige of some such element in the same place, the latter tooth being presumably more worn than in the Oeningen specimen. In the p. 2 of *Lagomys* the outer enamel bordering of crescent *b* is raised into a strong triangular cusp, turning its convexity inwards; in the fossil the inner border of the crescent is raised in the same manner.

The anterior premolar (p. 3) of the Oeningen fossil is not dissimilar from the same tooth of *Prolagus Oeningensis* (Kön.). Whereas in recent *Lagomys* the triturating surface of p. 3 exhibits only one enamel folding, starting from about the middle of the anterior margin and running backwards obliquely, i.e. postero-externally, the same tooth in our *Lagopsis* shows, as in *Prolagus Oeningensis*, *two* enamel foldings, opening on the anterior margin and thence running almost straight backwards.

These differences from *Lagomys* strengthen the opinion enounced by Schlosser, that the Miocene fossil is to be considered as a separate genus (*Lagopsis*), and at the same time they present a further link in the gradual transformation of the tooth-pattern (*Titanomys—Prolagus—Lagopsis—Lagomys—Lepus*), which begins in the hind-most molar of Lagomyidae, and gradually proceeds forwards, stopping at p. 1 in *Lagopsis* and *Lagomys* and at p. 2 in *Lepus*. This is not the place to enter into the details of this interesting evolution, which is exhaustively described elsewhere.

I append the measurements of the teeth described and of some of the bones of the same specimen, No. 42,815.

	mm.
Length of the three upper premolars	5·5
Breadth of p. 1	3·5
,, p. 2 (posteriorly)	3·5
,, p. 1	2·0
Length of scapula	32·5
,, humerus	36
,, ulna	36
,, femur	47

We have, then, been able to demonstrate conclusively that *Lagopsis verus* (Hens.) is a member of the fauna of Oeningen. It is not, however, in the least certain that all the large-sized Lagomyidae of the same deposit belong to this species, nor even to the genus *Lagopsis*; for my part I am looking for the discovery of *Titanomys Fontannesi* (Dep.) amongst Oeningen fossils. If the Carlsruhe specimen still exists, and is in the same condition in which it was figured by H. v. Meyer, a careful developing would doubtless give good results and allow of an exact determination .

3. Cricetodon minus, Lartet.

The genus *Cricetodon* is now for the first time mentioned as a member of the fauna of Oeningen. In previous lists of the mammals from this locality, the latest of which is by Depéret,[1] the genus *Mus* is enumerated; this appears to me very doubtful, the latter genus having never been met with in contemporaneous deposits.

In the Catalogue of Fossil Mammalia of the British Museum,[2] two skeletons of Oeningen from the Breda Collection figure under the heading '*Mus* (?), sp.' In one of these, No. 42,823, of which slab and counterpart are preserved, I have laid bare a molar tooth which proves to be the anterior right lower molar of a *Cricetodon*, corresponding in its size and in the character of a unicuspidate anterior tubercle to *Cricetodon minus*, Lartet, from Sansan, La Grive-Saint-Alban, Steinheim, etc.

The specimen No. 42,822, also from Oeningen,[3] is not a '*Lagomys*,'

[1] Ch. Depéret, "Classif. et Parall. du Système Miocène": Bull. Soc. Géol. France, 3e série, xxi, p. 245 (1893).

[2] I, p. 227.

[3] Cat. Foss. Mamm., i, p. 258.

but most probably a *Cricetodon minus*; the only molar present is so much worn that I cannot be positive on the subject.

EXPLANATION OF PLATE XVII.

Skeleton of the type-specimen of *Sciurus Bredai*, H. v. Mey. Two-thirds nat. size. Middle Miocene: Oeningen.

R.M., right maxilla; L.M., left maxilla; R.S., right scapula; L.S., left scapula; L.H., left humerus; R.R., right radius; R.U., right ulna; L.R., left radius; L.U., left ulna; R.C., right calcaneus; R.Fi., right fibula; R.T., right tibia; L.F., left femur; L.Fi., left fibula; L.T., left tibia; C., left calcaneus; I, II, III, IV, first to fourth left metatarsals.

NOTICES OF MEMOIRS.

PRELIMINARY NOTICE OF THE ETCHEMINIAN FAUNA OF NEWFOUNDLAND. By G. F. MATTHEW. [Bull. Nat. Hist. Society of N. Brunswick; St. John, N.B., June, 1899.]

THIS paper describes in outline the species obtained from the Etcheminian rocks (below the Cambrian) in Newfoundland.

The former is interesting as showing a departure from the groupings of genera found in the Cambrian. Trilobites are said to be absent or rare; there is a great preponderance of Hyolithidæ, which are present in several different types (*Heyolithes, Orthotheca, Urotheca*, n.gen.). The other classes of animals present are all small, or even minute, except Capulidæ among the Gasteropods. The classes recognized are Brachiopoda, Gasteropoda, Lamellibranchiata, Annelida, and Crustacea. The genera are *Kutorgina, Obolella, Scenella, Randomia* (n.gen.), *Parmophorella* (?), *Platyceras, Modiolopsis, Urotheca, Helenia, Hyalithellus* (?), *Coleoides, Orthotheca, Heyolithes*, and *Aptychopsis*.

Three plates of figures accompany the article, which is supplementary to a description of the stratigraphy, etc., of the terrane in which the fossils are found, and which description appeared in the Annals of the New York Academy of Sciences, vol. xii, No. 2, pp. 41, 56.

REVIEWS.

LIFE AND LETTERS OF SIR JOSEPH PRESTWICH, M.A., D.C.L., F.R.S., F.G.S., FORMERLY PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF OXFORD. Written and Edited by his Wife. 8vo; pp. xvi and 444, with 24 illustrations. (Edinburgh and London: William Blackwood & Sons, 1899.) [1]

THIS book forms a most expressive and touching memorial from the pen of Lady Prestwich to her husband, and is embellished, as such a memorial should be, with portraits of himself in middle life and in his later years; of the ancient home of his family, "Hulme," near Manchester; of his new home, "Darent Hulme," Shoreham, Kent, where he happily spent so many of his later years;

[1] For a life of Professor Joseph Prestwich see also GEOL. MAG., Dec. III, Vol. X (1893), p. 241 (with a portrait).

together with a series of portraits of his old friends and contemporaries: we should have welcomed also a portrait of that devoted partner, who for twenty-four years shared his scientific labours at Oxford and at Shoreham, and who aided Sir Joseph Prestwich so materially in bringing out his great work on geology,—the niece of his lamented friend Dr. Hugh Falconer.

To those who, like the present writer, knew Sir Joseph Prestwich well, this volume serves to recall not only many events of personal interest now almost forgotten, but also much of the contemporary geological history of the past half-century, in the midst of which Prestwich occupied so prominent a place, and took such an active part in helping to build up our science, contributing personally so largely to its records.

We make no apology for quoting at considerable length from the admirable summary of the scientific work of Sir Joseph Prestwich, given at the end of the present volume, by Sir Archibald Geikie, D.C.L., F.R.S., whose facile pen always affords pleasure to the reader. (See pp. 402–421.)

"The scientific career of Joseph Prestwich was marked by the long period over which it extended and by the wide range of subjects within the domain of Geology which it embraced. For more than sixty years, with indefatigable industry, he continued to contribute original observations and reflections to the science to which he had dedicated his life. His writings cover almost the whole field of geology. He discussed the various agencies, epigene and hypogene, which are now giving rise to geological changes on the earth. He studied the various geological formations from the Old Red Sandstone to the most recent gravels, but specially devoted himself to the Older Tertiary and Quaternary series. He gave much thought to the practical applications of geology, and led the way in pointing out the intimate relation between water-supply and geological structure. And lastly, he gave the world the benefit of his ripe experience and long reflection in the text-book in which he took a philosophical survey of the whole realm of geological investigation." [1]

"To gain a general idea of the nature, extent, and value of his scientific work, it will be convenient to subdivide his writings according to the several branches of geology which they illustrate. For this purpose we may first consider his contributions to our knowledge of the causes that produce geological changes, and the effects to which they give rise.

"From an early part of his scientific studies Prestwich paid close attention to the influence of running water on the face of the land. His interest in this subject was greatly quickened by his observations in connection with the high-level and low-level gravels of the river-valleys in the south-east of England and the north-west of France. From these deposits he drew the important conclusion that the

[1] This work is entitled, "Geology: Chemical, Physical, and Stratigraphical." By Joseph Prestwich. In two vols. (vol. i, Chemical and Physical, pp. xxiv and 477, with 218 illustrations, Oxford, 1886; vol. ii, Stratigraphical and Physical, pp. xxviii and 606, with 256 illustrations, Oxford, 1888. Royal 8vo. Clarendon Press, Oxford.

valleys have been mainly eroded by the rivers which still flow in them. Though this explanation of river-valleys was strongly insisted upon by Hutton and Playfair, and had been demonstrated for Central France by Desmarest and afterwards by Scrope and Lyell, it had never attained wide acceptance among geologists. When it was adopted and enforced by Prestwich on a basis of well-ascertained fact, it came almost with the freshness of a new discovery. He quickly saw its significance in regard to the slow sculpture of the face of the land, and the great antiquity which it proved for the older and higher terraces of gravel. In his memoir read before the Royal Society in 1862, he dwelt on the evidence that could be adduced of powerful and long-continued erosion in the valleys by the streams that still flow in them; and he continued to bring forward additional proofs in support of his views, until geologists everywhere admitted the validity of his reasoning. There remained, indeed, differences of opinion as to the intensity of the operations by which the denudation had been effected. The followers of Lyell would not admit that the observed facts demanded the existence of larger rivers and more powerful floods than might be witnessed at the present time, while Prestwich was always prepared to find that the geological agents had worked on a grander scale in former times than they do now. But the fundamental fact, that the valleys of the south-east of England and the north-west of France had been carved out by the action of the rivers that drain them, was now accepted without further demur."

"To Prestwich, therefore, must be assigned a not inconsiderable share in promoting the advance made during the last thirty years in the investigation of the history of terrestrial topography. He continued to interest himself in the subject up to the end of his life. Some of his last contributions to science dealt with the carving out of the river-valleys around his home at Shoreham and in the neighbouring district of the Weald." (p. 404.)

"It is interesting to note that Prestwich began his geological career by studying in minute and patient detail the coalfield of Coalbrookdale, and that he was thereafter led to explore the Old Red Sandstone of the Moray Firth. This early work was so eclipsed by the brilliance of his later researches among much younger formations, that a later generation of his contemporaries hardly realized the rare excellence and originality of his first great essay. The elaborate memoir on Coalbrookdale, presented to the Geological Society when its author was only a young man of twenty, is certainly a remarkable performance. Those to whom it was first addressed can hardly have failed to recognize in its author one of the future leaders of English geology. Selecting an area of about one hundred square miles, he carefully mapped its geology on a scale of one inch to a mile. The map was no mere sketch, but an elaborate survey, wherein the outcrops of the several seams of coal were traced, and the positions and effects of all the principal dislocations were represented. The structure of the ground was further displayed in a series of horizontal and vertical sections, while additional details

were given in an excellent descriptive memoir, combining a complete account of the stratigraphy and palæontology of the district. The list of fossils, together with plates of new species, form an important feature in this publication. Not only were the organic remains of the several formations discriminated, but even the characteristic forms of successive horizons were distinguished, and the bearing of the palæontological evidence on the geological conditions of deposit were luminously discussed. This Coalbrookdale monograph must be regarded as one of the classics of English geology, making a notable advance in the progress of stratigraphy, and serving as a model for subsequent investigation of the geological structure of our coalfields. It appeared before the then recently organized Geological Survey had mapped any of those parts of the country, and it is remarkable how closely the mapping of the Survey in subsequent years followed the lines which he had laid down."

"But, unquestionably, the most important of Sir Joseph's original contributions to science are to be found in the series of papers which he wrote on the older Tertiary formations of the South-East of England, and on the younger deposits containing the earliest traces of man. This brilliant work was begun, carried on, and completed during the scanty intervals of leisure which he could snatch from a busy mercantile life. Properly to understand its scope and value we must go back to the earlier decades of this century, and take note of the vague and confused ideas then entertained by geologists as to the arrangement and stratigraphical value of the series of deposits that overlie the Chalk. The term London Clay had been applied by William Smith to those deposits from the argillaceous character of their chief member. Subsequently various geologists noticed the occurrence of a group of sandy and clayey strata between the main mass of the London Clay and the top of the Chalk. These were grouped together as Plastic Clay and Sand, but their true stratigraphical value and palæontological interest were hardly recognized. In the year 1846 Prestwich published the first of a long series of papers in which he gradually worked out the true relations of the several members of the series, and brought them into relation with their equivalents in France and Belgium. The story of this evolution of clear order out of the confusion that had preceded Prestwich's researches has been well told by Mr. Whitaker, who has followed so worthily in the footsteps of the pioneer whose labours he chronicles.[1] Beginning among the cliff sections of the Isle of Wight, Prestwich traversed every part of the Hampshire and London Basins, recording his observations on copies of the Ordnance Maps and in voluminous notebooks. From year to year he communicated his results to the Geological Society, each paper throwing new light on the history of the geological formations, until in 1854 his great essay on the Woolwich and Reading Series added the coping-stone to the edifice he had so patiently reared. He showed that between the top of the Chalk and the base of the London Clay a group of strata, which he had called the 'Lower

[1] "The Geology of London": Mem. Geol. Surv., vol. i (1889), p. 88.

London Tertiaries,' was capable of a threefold arrangement into—1st, the basement-bed of the London Clay; 2nd, the Woolwich and Reading Series; and 3rd, the Thanet Sands. Tracing out the range and general physical features of the middle group, he brought forward numerous sections showing the local variations of the sediments from Hampshire to the east of Kent. He gave ample lists of the fossil contents of the strata, and discussed them in their bearings on the geographical conditions under which the deposits were accumulated. For the first time the succession of geological events recorded in the oldest Eocene strata of England was clearly stated."

"After reducing to order the older Tertiary series of England, Prestwich conferred a still further service on geology by bringing the English formations into line with those of France and Belgium. In a series of elaborate papers communicated to the Geological Society he established the correlation of these deposits, both lithologically and palæontologically, and in so doing became the acknowledged leader in the Tertiary geology of Western Europe." (p. 410.)

"To one of his investigations in later Tertiary geology reference may here be made as an instance of his sagacity of observation. He had long been acquainted with certain ferruginous sands scattered over the North Downs from Folkestone to Dorking. He recognized these materials to be different from the red flint drift or loam, on the one hand, and from the outliers of older Tertiary sands and pebble-beds on the other. In 1854 some highly ferruginous parts of these deposits yielded a number of casts of shells which were regarded by some palæontologists as indicating the base of the London Clay. Prestwich, however, assigned them to a much more recent period. He shared the opinion of Searles Wood, who regarded them as probably of the age of the Lower Crag. More recent observations by Mr. Clement Reid, of the Geological Survey, and the discovery of other and better preserved fossils, have left no doubt that Prestwich was entirely justified in looking upon these remnants of a once extensive deposit as Pliocene."

"Outside the rank of geologists Prestwich was probably best known for his connection with the establishment of the antiquity of man, and for his share in bringing home to the English public the enormous importance of geological knowledge in dealing with water-supply and other questions of every-day occurrence."

When in the Spring of 1859, at the suggestion of Dr. Hugh Falconer, he undertook to investigate the alleged proofs of the occurrence of flint implements, together with the remains of extinct mammalia in some of the old valley-gravels of the north of France, he entered on the inquiry with no very sanguine hope of finding that there was any good ground for the contention of M. Boucher de Perthes, who some ten years before had proclaimed his belief in the remote antiquity of the human race. But the evidence proved so strong as entirely to satisfy him that the French observer, who had met with but scant support or sympathy, was nevertheless right in his main conclusion. It was important to establish the fundamental

fact that man was a contemporary of the long extinct mammals whose bones were found lying beside his flint weapons in beds of undisturbed gravel, and further to show that the deposit of this gravel, though referable to a comparatively late geological period, must be older than the present configuration of the ground. Prestwich lost no time in communicating the results of his examination of the Abbeville region to the Royal Society. He cautiously abstained from pronouncing on the antiquity of man, contenting himself with pointing out that though there could be no doubt that man was contemporary with certain extinct forms of elephant, rhinoceros, deer, and other animals, no evidence had yet been obtained to show the chronological value of the interval that had elapsed since the deposit of the gravels containing the worked flints. He himself was at first inclined, not so much to throw the human period indefinitely backward, as to bring down the period of the extinct mammalia nearer to our own day, and to account for their disappearance and for the modification of the superficial topography by some sudden or rapid geological change, which, though transient, was powerful enough to leave its memorial on the surface of the land. As his investigations proceeded he felt the weight of evidence continually augmenting in favour of the long lapse of time required for the excavation of the valleys and for the production of the vast changes in the configuration of the land since the accumulation of the implement-bearing gravels. In his next great memoir, published in 1864, he admitted that 'we must greatly extend our present chronology with respect to the first existence of man; but that we should count by hundreds and thousands of years is, I am convinced, in the present state of the inquiry, unsafe and premature!' In this valuable essay, the whole evidence of the valley-gravels and of the gradual erosion of the valleys is marshalled with great skill, and discussed with characteristic clearness and caution. In later essays he admitted that man was living in Glacial or Post-Glacial times, which came down approximately to within 10,000 or 12,000 years of our own day.

"Thus it is to Prestwich, more than to any other geologist, that we owe the establishment of the fact that man coexisted with a number of now long extinct mammals, and that his advent on the earth must be relegated to a far higher antiquity than that which had been previously accepted. While he was engaged in the researches that led to these results he at the same time greatly enlarged our knowledge of the later phases of the Ice Age, particularly in the river-valleys of the south of England and north-west of France. The term 'Drift' has been vaguely applied to a multifarious series of superficial deposits, differing widely from each other in origin and in age. Prestwich strenuously contended for the local origin of the gravels in which flint implements and mammalian remains occur together. He showed that these accumulations unquestionably belonged to the river-systems within which they are found, that they were fluviatile in origin, and were deposited by the streams which still flow in the same valleys. He maintained, however, that

the rivers were formerly vastly larger than they now are; that, in virtue of their size, width, and transporting power, they were able to carry downward and spread out over their flood-plains the widely distributed sheets of course shingle now remaining; while from time to time they rose in floods of extraordinary magnitude that deposited the fine silt, containing land-shells, which is now to be seen covering all the different gravel-beds. Considerable differences of opinion still exist, however, regarding some of these deductions. Other observers, as remarked above, have been unable to perceive any satisfactory evidence that the rivers were generally more swollen than they are at present, though at exceptional periods of melting snow they may have surpassed in volume any floods chronicled in their valleys during historic times. But Prestwich detected the traces of another transporting agent than that of mere unaided river-water. In the presence of large unworn blocks among the ancient gravels, together with much sharp angular detritus, he recognized the operation of river-ice. Thus, all over the south-east of England, where the climate is now so mild, he traced indications that in old times the rivers flowing on the platform of the higher gravels were frozen over; that ice forming along their margins or over their bottoms lifted and carried along the shingle and boulders lying there, and that when these Arctic conditions prevailed, man had already appeared, fishing in the rivers, or tracking the mammoth, the bison, and various extinct forms of deer through the surrounding forests and prairies."

"Among Prestwich's contributions to the history of the latest geological changes that have affected the South of England and North of France, his numerous papers on the so-called Raised Beaches of this region deserve recognition." (p. 415.)

"One of the most useful services rendered by Sir Joseph Prestwich to the cause of his own science was the active share he took in the practical applications of geology. His labours in this department were manifested in two different directions. In the first place, he, more than other geologists of his day, insisted on the necessity of a knowledge of geological structure in dealing with the question of water-supply. From his early communication to the Institute of British Architects down to his pamphlet on the Oxford Water-Supply, an interval of thirty-five years elapsed, during which he came to be regarded as the leading authority on this subject in England, and his co-operation doubtless added much to the value of the Report of the Royal Commission on Water-Supply issued in 1869. It is to be regretted that the maps prepared by him for this Report were never published. In the second place, his early devotion to the coalfield of Coalbrookdale gave him a knowledge of our Carboniferous system, and an interest in its development, which he turned to good use in later years, when he acted as a member of the Royal Commission on Coal. Not the least valuable part of that important and voluminous work was supplied by him in his papers on the quantity of unwrought coal in the coalfields of Somerset, and on the probability of finding coal under the newer formations of the

South of England. In the last-named paper he gave a resumé of all that had been ascertained up to the year 1866 regarding the possible extension of the Coal-measures, and gave good grounds for supporting the conclusions of Godwin-Austen, and for believing in 'the high probability of the existence of basins [of coal] under the Secondary and Tertiary formations of the South of England.' This opinion, and the reasoning on which it was based, have recently acquired fresh interest and value from the successful borings for coal in Kent." (p. 418.)

"It may not be inappropriate to refer here to the influence which Prestwich exerted on his scientific contemporaries. The writer of these lines, who knew him well for many years, may perhaps be permitted to bear his testimony to the remarkable and perennial charm of his personality. While we revered him as one of the last of the old heroic race of geologists; while we honoured him for the endless enthusiasm and perseverance with which, often in the midst of many hindrances, he devoted every leisure moment to the cause of geology; while we admired him for his infinite patience, the scrupulous caution, and the laborious exhaustiveness of his researches, we loved him for the gentle, child-like simplicity of his heart, his unaffected modesty, and his genuine goodness. His bright sunny temperament always found out what was best in those with whom he came in contact. His unfailing sympathy delighted to find expression in active helpfulness. The smile that lighted up his handsome features seemed to reveal at one glance the tenderness, kindliness, and truthfulness of his nature. One felt after an interview with him cheered and brightened by contact with one whose serene old age seemed to place him so far above the littleness and troubles of life. While his writings will perpetuate his scientific achievements, it should be placed on record that it was not these achievements alone which gave Sir Joseph Prestwich his pre-eminence among his contemporaries, but that he owed this position in large measure to the integrity and charm of his character." (p. 421.)

Sir Joseph Prestwich's career most aptly illustrates the proverb—"The child 's the father of the man." Beginning from his earliest youth with remarkable habits of application to study, with great industry and self-denial, coupled with an intense love of science and a keen desire to be a geologist, he yet submitted, from a strong sense of duty and obedience, to work at his father's city business from 18, and so went on until he was 60 years of age. During those forty-two years of uncongenial mercantile cares, Prestwich squeezed into their leisure hours a lifetime of scientific work, such as few men could have accomplished had they devoted all their existence to it, unhindered by any business calls or anxieties whatever.

The following are a few of Sir Joseph Prestwich's leisure-hour achievements:—138 published scientific books, memoirs, and papers. Elected an F.G.S. in 1833, elected and served on the Council of the Geological Society 1846–68, one of the founders of the Palæontographical Society 1847, elected an F.R.S.

in 1853, served as one of the Secretaries of the Geological Society 1855, became Treasurer of the Geological Society 1856–63, appointed a Royal Commissioner on Water Supply 1865, appointed a Royal Commissioner on Coal Supply 1866, elected President of the Geological Society 1870–72, Vice-President of the Royal Society 1883. In 1849, when only 37 years of age, Prestwich received the "Wollaston Gold Medal." On 23rd June, 1874, when 62 years of age, having already accomplished a lifetime of work, he was elected Professor of Geology in the University of Oxford, as successor to Professor John Phillips, F.R.S., a Chair which he held for fifteen years, retiring in 1887, at the age of 75 years! In 1874 the Telford Gold Medal and premium were awarded to Professor Prestwich for his paper on "The Geological Conditions affecting the Construction of a Channel Tunnel." He was made an Honorary D.C.L. (Oxon) in 1888, and received knighthood in 1895 (æt. 84). Truly it may be said of Sir Joseph Prestwich in the words of Chaucer—

"He was a verray perfight gentil knight." H. W.

CORRESPONDENCE.

NOTE ON *AMMONITES EUOMPHALUS*, SHARPE.

Sir,—The *locality* given by Sharpe for his type of this Ammonite is quite wrong. Dr. Rowe and myself have just returned from a survey of the Dorset coast, and Mr. Crick has shown me the type. The matrix of Sharpe's specimen is identical with that of the specimen from Humble Point collected by us, and closely approximates to the matrix of the specimen collected by the Geological Survey. There is no matrix anything like it in Man o' War Cove, nor is there anything like it in any of the Dorset coast sections. It undoubtedly came from the Whitland's section in Devonshire.

This is an excellent example of the confusion caused by accepting any previous records, when attempting to do zonal work or make tables of occurrences. The fossils should be personally collected by those who are responsible for the stratigraphy; error is then reduced to a minimum. C. Davies Sherborn.

OBITUARY.

SIR WILLIAM HENRY FLOWER,

K.C.B., LL.D., D.C.L., D.Sc., F.R.C.S., Ph.D., F.R.S., F.L.S., F.G.S., Pres.Z.S., KNIGHT OF THE PRUSSIAN ORDER "POUR LE MÉRITE," ETC., ETC., ETC.

Born November 30, 1831. Died July 1, 1899.

Few men have had the satisfaction to see so large a share of their hopes and ambitions in life realized as Sir William Flower.

Born in the historic town of Stratford-on-Avon, where his father's family had already resided for many years, he had the good fortune to be the second son, and was consequently permitted, from his youth up, to pursue that innate love of natural history which springs eternal in the schoolboy breast, but seldom lasts till manhood. In

young Flower's case it was to last a lifetime, for it was fostered through his being early brought in contact with that veteran naturalist and geologist, the Rev. P. B. Brodie, M.A., F.G.S., who was the first person, as Flower himself informed the writer, to inspire him with a taste for collecting fossils and other natural-history objects, and to stimulate his powers of observation in the field as a zoologist.

After his schooldays were over, he matriculated at the University of London in 1849, with honours in Zoology, and in the same year he entered the Medical Classes at University College and became a pupil at the Middlesex Hospital. Here he gained the gold medal in Dr. Sharpey's class in Physiology, and the silver medal in Zoology, and passed the first M.B. of the London University in 1851. In 1854 he became a member of the Royal College of Surgeons; he shortly afterwards joined the 63rd Regiment, and embarked for Constantinople, war with Russia having just then been declared. The sufferings of the British Army in the Crimea are now a matter of history, and young Flower, who passed the first winter with his regiment there, experienced all the severity of the climate, officers and men being alike without tents and even necessary warm clothing, suffering from frostbite and exposure for many weeks every night in the open air. Mr. Flower, who was never of a very robust constitution, at length broke down and was invalided home; soon after receiving, at the hands of the Queen, the war-medal with clasps for the Alma, Inkermann, Balaclava, and Sebastopol.

Shortly after his recovery, he joined the staff of the Middlesex Hospital as Demonstrator in Anatomy, and resigned his position in the Army in order to settle and take a practice in London. In 1857 he passed the examination for the Fellowship of the Royal College of Surgeons, and next year was elected Assistant-Surgeon to the Middlesex Hospital, holding also the office of Curator of the Museum and Lecturer on Comparative Anatomy in the same institution.

In 1858 he married Georgiana Rosetta, youngest daughter of Admiral W. H. Smyth, F.R.S., the well-known Astronomer and Hydrographer.

In 1861 the important office of Conservator of the Museum of the Royal College of Surgeons of England, commonly called the "Hunterian Museum," became vacant by the death of Professor Quekett. The collections under the Conservator's charge were most extensive, and very varied in their nature, embracing Surgery, Pathology, Anatomy, Physiology, Zoology, and Palæontology, and some knowledge of these diverse subjects was required by the occupant of the office. The appointment was, however, congenial to Mr. Flower's tastes, and for it he gladly relinquished the practice of his profession and his connection with the Middlesex Hospital; he henceforth devoted himself wholly to scientific pursuits. The care of the Museum and its complete reorganization and gradual augmentation constituted for many years his principal employment, every department having unfortunately fallen into arrears, as regards cataloguing and arrangement, at the time he took charge

of it. The Hunterian Professorship of Comparative Anatomy and Physiology (which for twenty-five years had been held in conjunction with the conservatorship of the Museum by Professor Owen) had been separated from it some time previously, and was then held by Professor Huxley, who, however, was compelled by the pressure of other engagements to relinquish it in 1869, when the two offices were again united by the appointment of Mr. Flower to the Professorship, the duties of which consist in the delivery of a short course of lectures, on different subjects each year, illustrated by the preparations in the Museum.

Professor Flower was elected a Fellow of the Royal Society in 1864, and served several times on the Council. In 1879, on the death of the Marquis of Tweeddale, President of the Zoological Society, he was elected to succeed him in that office, and he held the Presidency up to the time of his death, a period of twenty years; he had previously served for years on the Council and as one of the Vice-Presidents. He was elected a Vice-President of the Anthropological Institute of Great Britain and Ireland in 1879, and President in 1883.

In connection with the British Association for the Advancement of Science, he has held the offices of Vice-President of Section D (Biology), Norwich, 1868; President of the same section at Dublin, 1878; President of the Section of Anthropology at York, 1881; of Biology at Oxford, 1894; and President of the British Association at Newcastle-on-Tyne, 1889. He was also President of the Section of Anatomy at the International Medical Congress in 1881. He was several times Examiner for the Natural Science Tripos in the University of Cambridge, and delivered lectures at the Royal Institution, Albemarle Street.

In 1884 Professor Flower was appointed Director of the Natural History Departments of the British Museum, Cromwell Road, as successor to Professor Sir Richard Owen, retired; which post he held till October, 1898, when failing health compelled him to relinquish active work, and he was succeeded by Professor E. Ray Lankester, D.C.L., F.R.S., the present Director of that Institution.

The Royal Society awarded him one of its Royal Medals in November, 1882, for his contributions to the Morphology and Classification of the Mammalia, and to Anthropology. He received the honorary degrees of LL.D. of the University of Edinburgh and of Dublin in 1878, and D.C.L. of Durham in 1889. He was made a C.B. in 1887 and a K.C.B. in 1892.

Among Sir William Flower's contributions to Anatomy and Zoology may be mentioned "A Supplement to the Catalogue of the Pathological Series in the Museum of the College of Surgeons," 1863; "A Catalogue of the Series of Human Osteology," 1879; "Introduction to the Osteology of the Mammalia," 1870; "Fashion in Deformity, as illustrated by the Customs of Barbarous and Civilized Races," 1881; "Observations upon the Posterior Lobes of the Cerebrum of the Quadrumana," 1862; "On the Commissures of the Cerebral Hemispheres of the Marsupialia, as compared with those of the Placental Mammals," 1865; "On the Development and